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PALEONTOLOGY.—*A late Triassic terebratellacean from Peru.*[1]

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The brachiopod fauna of the present oceans consists predominantly of representatives of the Terebratuloidea. In this group the relation of the soft parts to the skeleton is relatively well known. For this reason they offer the most promising group within the Brachiopoda for purposes of evolutionary study. An excellent study (Cloud, 1942) of the basal terebratuloid stocks and their initial radiation during the late Silurian and Devonian furnishes a foundation for further work. In connection with studies undertaken for the *Treatise on invertebrate paleontology* the writer has completed a revision of Mississippian, Pennsylvanian, and Permian terebratuloids (unpublished). In combination these two studies reveal with reasonable clarity the major course of terebratuloid evolution during the Paleozoic.

Studies of recent forms have been carried back through the Tertiary (Thompson, 1927, and others), and many living genera are known to extend into the Cretaceous and some perhaps into the Jurassic as well. The main gap in our knowledge of terebratuloid phylogeny may be seen therefore to fall in the Triassic-Jurassic interval. As it happens it is during this interval, particularly the Triassic portion, that great innovations appear. Chief among these is the origin of the dominant modern superfamily, the Terebratellacea.

The recognition of Mesozoic terebratellaceans is frequently difficult. This difficulty arises principally in distinguishing them from other groups having long adult loops. The basic feature permitting separation of the terebratellaceans from these other groups is the metamorphosis of the loop during ontogeny and its intimate relation to the median septum. More or less complete ontogenetic series are therefore necessary for confident recognition.

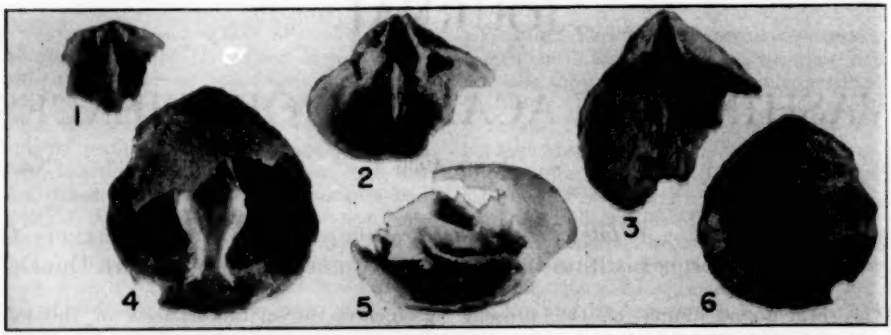
The earliest definitely known terebratellacean reported in the literature appears to be *Hamptonina* of the Middle Jurassic. Particular importance therefore attaches to an undoubted terebratellacean species recently recognized in a collection of silicified material from the late Triassic of Peru. The importance of this form as the earliest known member of the superfamily and its evolutionary significance has prompted the description which is presented below.

PRESENT MATERIAL

The species here in question is represented by at least twenty fragmentary silicified specimens. They have been freed of the matrix by acid etching. The fragments present abundant internal detail, but the external form of the shell is incompletely known. All specimens are believed to represent juvenile individuals because of the immature beak characters displayed and the presumably incompletely metamorphosed loop. All individuals are of about the same size and suggest that a high degree of sorting was effected during their transportation to the burial site. Because it appears undesirable to me to propose a name for immature specimens which cannot now be identified with any adult, the species is merely described and may await naming when more complete material becomes available.

All specimens were obtained from lot 74 of the Jenks collection of Peruvian Triassic from the Cerro de Pasco region. They are housed in the American Museum of Natural History in New

[1] California Institute of Technology, Division of the Geological Sciences, Contribution No. 768.



FIGS. 1–6.—An unnamed late Triassic terebratulloid brachiopod: 1, Interior of a fragmentary brachial valve showing the heavy median septum and the medially sessile cardinal plate with which it is connected; 2, interior of a fragmentary pedicle valve showing the open delthyrium and the dental plates; 3, interior of fragmentary pedicle valve showing the open, perhaps juvenile nature of the delthyrium; 4, more or less complete specimen showing the loop in place; 5, lateral view of the same specimen; 6, brachial interior of the same specimen.

York City. The strata from which lot 74 was collected have been dated on the basis of other fossils as late Triassic (Haas, 1953) and are part of the Pucara group.

DESCRIPTION

Shells small, the most complete specimen is 7.5 mm long, 7 mm wide, and appears to have been about 4 mm in thickness. The outline is slightly ovate; the pedicle valve is longitudinally and transversely convex; no fold or sulcus appears to be present, pedicle beak nearly straight; pedicle foramen unrestricted by deltidial plates, so that the delthyrium is open, and not transgressing on the apex of the beak. Brachial valve longitudinally and in general transversely convex but seemingly developing a shallow sulcus anteriorly.

Pedicle interior with short strong dental plates and a low myophragm dividing the muscle field and extending from the anterior

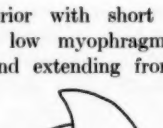


FIG. 7.—Profile of partly reconstructed individual.

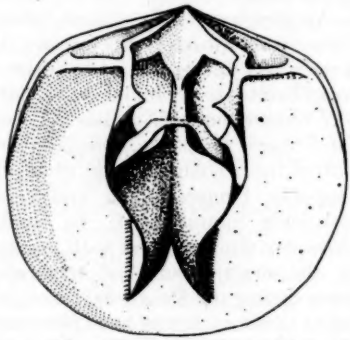


FIG. 8.—Diagrammatic reconstruction of the loop.

margin of the rostral cavity to about midlength, muscle scars poorly impressed. Brachial interior with the cardinal plate medially concave and supported by a low, broad septum which extends anteriorly past midlength to a union with the loop; crura arising from the inner margins of the socket plates; crural points small; main bands extend forward in an essentially centronelliform fashion and unite with the median septum and the remainder of the loop; recurving band consisting of two more or less vertically disposed plates which are concave inward and united at the apex of each concave surface; each plate arises from the median septum with which it is broadly joined by becoming gradually free at the lower margin; above their union with each other the two plates diverge only to be united posteriorly by a narrow transverse band which is not,

unfortunately, preserved in any specimen; the anterior extremities of the recurved band extend much farther forward than the main bands and bear spines as does the lateral margin of the main band; the positions of the muscle insertions cannot be determined.

DISCUSSION

The stage of loop development seen in this form does not closely resemble any stage in the development of the three major types distinguished by Elliott (1953) among modern forms. It most nearly approaches, however, the early stages of dallinid loop development. It seems probable that this form, if it can truly be referred to any modern family, should be placed in the Dallinidae. The principal basis for this conclusion is the general resemblance of the loop to that of the adult loop of the Cretaceous genus *Kingena*.

If these specimens are, as they seem to be, juveniles, this may account for the difficulty encountered in relating them to preexisting forms. Should they actually represent adults, the problem is even more difficult, for they do not closely resemble any known Paleozoic or Triassic genus. One possibility is that neoteny, an important feature in terebratuloid evolution, has intervened, obscuring relationships. Probably little more can be determined of the true relationships of this form until a comprehensive study of Triassic forms is carried out.

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BIOLOGICAL STUDIES AT POINT BARROW

The Eskimo birth rate is increased as much as threefold when the Arctic people eat "white man's food" instead of their traditional pure-animal diet of whale, fish, and seal. This is the observation of Prof. G. E. MacGinitie, of the California Institute of Technology, in a report recently published by the Smithsonian Institution on his biological investigations at the Navy's Arctic Research Laboratory at Point Barrow, on Alaska's Arctic coast.

"When hunting was the only means of subsistence," he writes, "Eskimo women became pregnant only once in several years, but with the new diet they bear a baby about every year. What will happen when outside support is shut off is an important and serious problem. Some few fathers are training their boys in hunting and other Eskimo skills, but most of them are content to let the future take care of itself. The situation is fast becoming a problem difficult of solution."

Of primary importance in the old Eskimo culture, Professor MacGinitie points out, is the bowhead whale. "Several," he says, "are taken in the spring of each year and the flesh is stored underground in cellars where it remains edible for three or four years. The whales feed on euphasiids, mysids, pteropods, and copepods, which are so abundant that the great blue whale can attain a weight of 60 tons in two years. Baleen whales probably lead the easiest life of any mammal. These enormous creatures have only to swim slowly through water, which has about the same specific gravity as themselves, opening and closing their mouths and swallowing food. To an Eskimo the most delectable food is whale muktuk, which consists of whale skin with about an inch of underlying blubber. After freezing, the muktuk is cut into small pieces and eaten raw. It has a nutty flavor and is really quite good.

"Perhaps next in importance in the native economy is the bearded seal. This marine animal, which reaches a weight of 500 to 600 pounds, feeds almost entirely on amphipods, using its whiskers for sweeping them from the underside of the ice. The teeth are very small and are of little use for holding or masticating food.

"In winter these seals are hunted in offshore leads. They float when shot, and so can be taken easily. In summer they are hunted in boats. Then they sink when shot and, if not immediately harpooned, are lost. On one summer hunt on which I accompanied my two boatmen, eleven seals were shot and seven were lost."

PALEOBOTANY.—*New items in Cretaceous and Tertiary floras of the western United States.* ROLAND W. BROWN, U. S. Geological Survey.

The fossil plant collections in the United States National Museum continue to enlarge as deposits are made by U. S. Geological Survey expeditions and by gifts from private individuals and institutions. Some of these increments come from localities and formations already known and exploited; but others are from strata not yet named and, therefore, contribute toward the dating of the strata as well as to a clearer concept of the species the plants represent. Rather than postpone their description to an uncertain time when monographic studies might be published they are presented now for such significance as they may have.

GLEICHENIACEAE

Gleichenites repenningi Brown, n. sp.

Fig. 14

Frond forked three times, but no arrested buds at the forks as in normal species of *Gleichenia*. Ultimate pinnules narrow, entire, rounded at the tips and separate almost to the rachis. Venation relatively simple, usually once but sometimes twice forked. No fruiting specimens found.

Although the general appearance of the frond and the venation of the pinnules suggest that the affinity of this fern is with the Gleicheniaceae, the assignment must be considered tentative.

The species is named for Charles A. Repenning, of the U. S. Geological Survey, who discovered the locality.

Occurrence.—In the Mesaverde group (Upper Cretaceous) at Black Mountain, about 40 miles southeast of Kayenta, Ariz. Collected by R. W. Brown et al., 1955.

SCHIZAEACEAE

Schizaeopsis dentata Brown, n. sp.

Fig. 13

Frond deeply incised, almost digitate, showing a kind of repeated dichotomy, the ultimate divisions narrow, but the tips not seen. Margin inconspicuously and remotely dentate. Venation forked, with a vein running into each marginal tooth. No fruiting structures found.

The reference of this fern to the Schizaeaceae must be regarded as tentative. In some features it may be compared with the living *Schizaea elegans* (Vahl) Swartz, of the American Tropics, and the epiphytic *Platycerium alcicorne* Desvaux, of East Africa. Neither of these, however, has marginal teeth. In the latter respect *Dipteris conjugata* Reinwardt of the East Indies, is somewhat comparable, but the main venation is more open and has numerous prominent cross-connections, which are absent in the fossil.

Perhaps the most striking resemblance of this fern is to specimens called *Pseudogingko bohemica* Velenovsky and Viniklar (1926, p. 8, pl. 5, figs. 1–15) from the Upper Cretaceous of Bohemia. The latter, however, lacks marginal teeth. That the present specimen and *P. bohemica* represent gymnosperms may well be questioned. Such uncertainty about even the higher rank allocation of fossils illustrates the frustration to which paleontologists are sometimes subject when definite clues are lacking.

Occurrence.—In the Mesaverde group (Upper Cretaceous) at Black Mountain, about 40 miles southeast of Kayenta, Ariz. Collected by R. W. Brown et al., 1955.

LEGUMINOSAE

Bauhinia wyomingana Brown, n. sp.

Fig. 1

Upper half of a leaf, evidently originally at least 10 cm long, deeply incised making a rounded sinus and two lobes. Only the top of the midrib present. Secondary veins strong, curving upward in the direction of the margin, the uppermost pair entering the apical lobes.

No pods were found with this leaf, but large pods, not yet identified, have been found at about the same stratigraphic level at neighboring localities in Wyoming, where, however, no leaves recognizable as those of *Bauhinia* occur. The deep sinus and bilobed feature of this leaf, together with the venational details, leave no doubt about its identification. It is the first species of *Bauhinia* to be reported from the Paleocene strata of the western States. One doubtful species, *B. pseudocotyledon* Cockerell, was described from the Oligocene lake beds at Florissant, Colorado. Several species have been identified in the Cretaceous and Eocene deposits of the Atlantic and Gulf coasts.

This leaf resembles those of several living species, of which there are about 150. They include

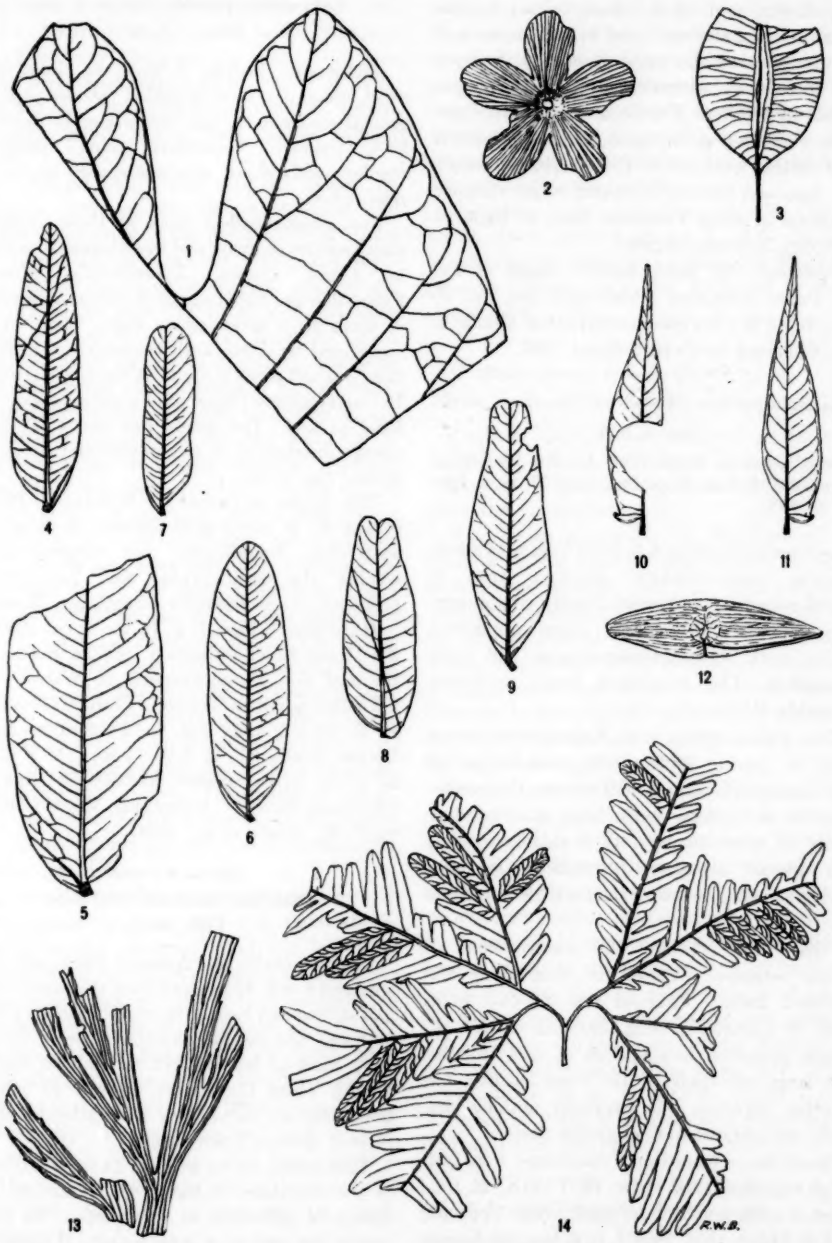

FIG. 1.—*Bauhinia wyomingana* Brown, n. sp. FIG. 2.—*Antholithes wellsi* Brown, n.sp. *Koelreuteria annosa* Brown, n. sp. FIGS. 4, 5, 6.—*Caesalpinia pacifica* (Knowlton) Brown, n. comb. FIGS. 7, 8, 9.—*Caesalpinia pecorae* Brown, n. sp. FIGS. 10, 11.—Counterparts of *Ailanthus eureka* Brown, n. sp. FIG. 12.—*Ailanthus lesquereuxi* Cockerell. FIG. 13.—*Schizaeopsis dentata* Brown, n.sp. Fig. 14—*Gleichenites repenningi* Brown, n. sp. All figures natural size.

trees, shrubs, and vines, closely allied to the redbuds, *Cercis*, and are found in the tropics and subtropics around the world. Some species have been introduced successfully as showy ornamentals in southern Florida and southern California. *Bauhinia wyomingana*, therefore, adds a bit of further evidence to that of palms, breadfruit, figs, and others, indicating warm climatic conditions in early Paleocene time in parts of the Rocky Mountain region.

Occurrence.—In lower lignitic strata of the Fort Union formation (Paleocene), sec. 14, T. 57 N., R. 85 W., 2¼ miles northwest of Monarch, Wyo. Collected by T. E. Williard, 1907.

Caesalpinia pacifica (Knowlton) Brown, n. comb.

Figs. 4, 5, 6

Quercus pacifica Knowlton, U. S. Geological Survey 20th Ann. Rept., pt. 3, p. 43, pl. 1, figs. 9, 10, 1900.

Asymmetric leaflets, 4 to 8 cm long with short, glandular, cross-wrinkled petioles. Apex in general rounded, only exceptionally emarginate. Base rounded. Secondary veins numerous, regular, with short intersecondaries and some reticulation. The lowermost basal secondary noticeably thickened.

This species differs from *Caesalpinia pecorae* chiefly in having leaflets with rounded rather than emarginate apexes. Otherwise, the resemblance is so striking as to suggest very close affinity or even identity. It is significant that both species are from formations regarded reliably as being not older than middle Eocene in age.

I have also collected this species from an Eocene sequence exposed in cuts along the Southern Pacific Railroad one to two miles north of Comstock, Oreg. Sanborn (1937), although reporting two species of *Lonchocarpus* from large collections at the same locality, has no other legumes and especially nothing definitely comparable to *Caesalpinia pacifica*.

Occurrence.—Knowlton's specimens from yellowish sandstone, NE ¼ sec. 16, T. 38 S., R. 1 E., about 5 miles north of Ashland, Oreg. Collected by J. S. Diller, 1898. Figs. 4, 5, 6, from an Eocene lignitic sequence near the Hansen coal mine, SW ¼ sec. 3, T. 37 S., R. 1 W., about 4 miles northeast of Medford, Oreg. Collected by R. W. Brown et al., 1940.

Caesalpinia pecorae Brown, n. sp.

Figs. 7, 8, 9

Asymmetric leaflets, 3 to 4 cm. long, with short, glandular, cross-wrinkled petioles. Apex in general emarginate, only exceptionally rounded. Base rounded. Secondary veins numerous, regular, with short intersecondaries and some reticulation.

Emarginate leaflets, such as these, occur in many species of living and fossil legumes, notably in *Acacia*, *Cassia*, *Eysenhardtia*, *Mimosa*, *Pithecellobium*, *Robinia*, and *Sophora*. Assignment of them to a given genus must, therefore, be considered tentative until confirmatory evidence like pods and seeds is found at the same localities. In the meantime *Caesalpinia* is perhaps as good a label as any. The genus has about 30 living species distributed in the tropics and subtropics around the world.

The species is named for William T. Pecora, of the U. S. Geological Survey, to honor his leadership, friendliness, and cooperation in solving the stratigraphic and paleontologic problems of the Bearpaw Mountains, Montana.

Occurrence.—Figs. 7, 9. In the upper strata of the Green River formation (middle Eocene) on the east side of the Bonanza to Watson road, 2.2 miles north of Watson, Utah. Collected by R. W. Brown, 1941. Fig. 8. In tuffaceous middle Eocene strata, SE ¼ NW ¼ sec. 11, T. 28 N. R. 14 E., in the western foothills of Centennial Mountain, Bearpaw Mountains, Mont. Collected by R. W. Brown et al., 1954.

SIMARUBACEAE

Ailanthus eureka Brown, n. sp.

Figs. 10, 11

Leaflet notably asymmetric, lanceolate, 4 cm long and 8 mm wide. Apex long attenuate. Lower half of rounded base with one prominent glandular tooth, the margin otherwise entire. Secondary veins more or less straight to the area near the margin where they curve upward to join the the secondary above. Few short intersecondaries present. Petiole 2 mm long.

This leaflet, so far as I am aware from perusal of the literature, is the first unequivocal fossil foliage of *Ailanthus* to be reported. Its finding marks the end of a long search. Hitherto, the assignment of leaflets to the same species as well recognized seeds from the same localities has left much to be desired in that none of the leaflets so assigned has clearly shown the characteristic

basal, glandular teeth (Brown, 1940, p. 351; 1946, p. 350). All the features of this leaflet, however, but particularly the glandular tooth, are consonant with those seen in most species of living *Ailanthus*, the one exception being *A. excelsa* Roxburgh, which has toothed leaflets without glands.

No samaras were found with this leaflet. Its associates, however, are species of leaves and fish like those found in the middle Eocene Green River formation in Colorado, Utah, and Wyoming, thereby attesting its Eocene age. On the other hand, the beautiful samaras of *Ailanthus lesquereuxi* Cockerell (Fig. 12) from the Green River formation at Fossil, Wyoming, although found with many other species of leaves, fruits, and seeds, are not accompanied by leaflets clearly assignable to *Ailanthus*. As the samaras of *Ailanthus* found in many western Tertiary deposits from the Eocene to the Miocene epochs are very similar in features, they cannot well be distinguished as separate species; but a number of such species have been described. The question now arises: Should the present leaflet be called *A. lesquereuxi* or should it be a new species? I choose the latter alternative, pending the finding of samaras at the same locality, or the finding of similar leaflets in the Green River formation, that may show its true relationship to *A. lesquereuxi*.

The leaflet is relatively small as compared with those of living species. Perhaps it is abnormal and not typical of its species. The finding of recognizable *Ailanthus* leaflets in the Green River and other Tertiary floras is, therefore, an eventuality earnestly hoped for.

Why are these leaflets rare in the fossil record? I can suggest in reply only the implications hinted at in my observation of the leaves of *Ailanthus altissima* (Miller) Swingle, the common Asiatic tree-of-heaven, planted or escaped in many parts of the north temperate zone. When the large compound leaves fall they disintegrate quickly, the leaflets remaining intact for only a few days. On the ground they become fragile and crumble easily. Unless, therefore, such leaflets fortunately fall into water and are speedily buried in bottom sands and muds, there is little chance that they will be preserved as fossil specimens.

Species of *Ailanthus* in the Tertiary record of the western States, like those of *Cercidiphyllum*, *Ginkgo*, *Keteleeria*, *Koelreuteria*, *Metasequoia*, *Pseudolarix*, and many others, indicate a former widespread distribution in the North Temperate zone of entities whose remaining relatives are now restricted to indigenous Asiatic floras. The presence of any one of these in a fossil flora from the American west prompts an inspection of the living Asiatic flora for possible matches to other specimens seemingly unidentifiable in terms of local or neighboring species.

Occurrence.—In tuffaceous middle Eocene strata, SE ¼ NW ¼ sec. 11, T. 28 N., R 14 E., in the western foothills of Centennial Mountain, Bearpaw Mountains, Mont. Collected by R. W. Brown et al., 1954.

SAPINDACEAE

Koelreuteria annosa Brown, n. sp.

Fig. 3

Capsular valve, 2.7 cm long and 1.8 cm wide. Elliptic in outline, with apex missing. Peduncle 5 mm long. Venation relatively simple, with a few forks and anastomoses.

No foliage assignable to *Koelreuteria* was found with this characteristic capsule. In size it is somewhat smaller than that of *K. nigricans* (Lesquereux) Brown (Brown, 1946, p. 350) from the middle Eocene Green River formation, to which, on account of its geographic contiguity, it might have been closely related. *K. annosa*, however, is from lignitic strata near the top of the Fort Union formation (Paleocene) northeast of Point of Rocks, Wyo.

Several species of *Koelreuteria* have been recorded from the Tertiary rocks of the western States, but this is the first from the Paleocene series. It belongs with a group of species of other genera whose living descendants or relatives are now restricted to Asiatic habitats. One species, *K. paniculata* Laxmann, the so-called goldrain-tree, an exotic to the parks of the United States, makes a showy display with its mass of golden flowers and its Chinese lanternlike seed pods.

Occurrence.—In the upper lignitic strata of the Fort Union formation (Paleocene), NW ¼ SW ¼ sec. 36, T. 21 N., R. 100 W., about 7 miles northeast of Point of Rocks, Wyo. Collected by William P. Severn, 1954.

UNCERTAIN AFFINITY

Antholithes wellsi Brown, n. sp.

Fig. 2

Five-parted calyx or corolla, the parts united at the base. Diameter 2 cm. Central area depressed to form a shallow cup. No evidence of stamens or pistils.

Although numerous leaves were found associated with these flowers, no definite suggestion of relationship or identity has developed from their study.

The species is named for Francis G. Wells, of the U. S. Geological Survey, to honor his long labors in elucidating the geology of Oregon.

Occurrence.—In an Eocene lignitic sequence near the Hansen coal mine, SW ¼ sec. 3, T. 37 S., R. 1 W., about 4 miles northeast of Medford, Oreg. Collected by R. W. Brown, 1954.

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DR. JOHN G. THOMPSON RETIRES

Dr. John G. Thompson, chief of the Metallurgy Division of the National Bureau of Standards, has retired after more than 35 years of Government service.

Born in Eau Claire, Wis., in 1894, Dr. Thompson attended Cornell University, receiving his bachelor of chemistry degree in 1915 and his doctor of philosophy in 1921. His association with the National Bureau of Standards began in 1921 when he became a member of the Chemistry Division. From 1924 to 1929 he was employed as a chemist and metallurgist at the Fixed Nitrogen Laboratory of the Department of Agriculture on problems in connection with the synthesis of ammonia. He returned to the National Bureau of Standards in 1929 as a research associate for the Cerro de Pasco Copper Corporation and the following year was appointed chief of the Chemical Metallurgy Section. He was appointed chief of the Metallurgy Division in 1946.

Dr. Thompson has made outstanding contributions in fields of research pertaining to the preparation of pure metals, the evaluation of their properties, gases in metals, special refractories, corrosion, and powder metallurgy, and is the author of more than 35 technical publications. The results of his studies of bismuth and bismuth alloys paved the way for industrial development of fusible alloys containing bismuth. Dr. Thompson was instrumental in developing a process that involved chemical purification of an iron salt and its subsequent conversion into oxide, sponge, and melted ingots. By the use of this process, he was successful in 1938 in producing an iron of 99.99 percent purity, the highest established purity to that time in this country or abroad. His book *The Metal—Iron* (co-authored with H. E. Cleaves) is an exceptionally valuable reference and was the basic volume of the series of monographs on alloys of iron sponsored by the Engineering Foundation. He was successful in extending the slip-casting process to the preparation of thin-wall crucibles of alumina, beryllia, and other special refractories that lacked the property of plasticity. Slip-cast beryllia crucibles were used in preparing the "super-pure" ingots of iron. The results of his work served as the basis for the production of slip-cast crucibles of special refractories by other laboratories.

Dr. Thompson was the leader of an international cooperative study that established the accuracy of the vacuum-fusion method for determining oxygen in the plain carbon steels, either as aluminum-killed, silicon-killed, or rimmed. He recommended procedures for obtaining optimum results by this method and subsequently extended its usefulness for determining oxygen in alloy steels. The vacuum-fusion method is now extensively used, not only as a tool for research but commercially, as the "standard" for determining the oxygen content of steels and other metals. During World War II he conducted researches on beryllium-aluminum alloys under the auspices of the War Metallurgy Committee; this work received an award from the Office of Scientific Research and Development. His study of the metallurgy of beryllium and uranium for the Manhattan Project was also recognized by an award from the War Department.

Since World War II Dr. Thompson has been honored by service as a Presidential appointment member of Annual Assay Commission for 1950, U. S. Mint, Philadelphia; member of the Materials Advisory Board of the National Research Council; member of Advisory Committee on Revision of New York State Industrial Code No. 21; chairman, Washington Chapter, American Society for Metals; and conferee, First World Metallurgical Congress, 1951. He has served on many technical committees of various engineering societies. He is an active member of the American Society for Metals, American Institute of Mining and Metallurgical Engineers, American Society for Testing Materials, National Association of Corrosion Engineers, British Iron and Steel Institute, British Institute of Metals, WASHINGTON ACADEMY OF SCIENCES, Sigma Xi, and the Cosmos Club.

BOTANY.—Calamochloa: *A Mexican grass.* ERNEST R. SOHNS, U. S. National Museum. (Communicated by Agnes Chase.)

The genus *Calamochloa* was described by Fournier (1877). His brief description was based on the single collection by the French mineralogist Pierre Virlet d'Aoust, no. 1461, from San Luis Potosí, Mexico, without precise locality. Other than the type specimen in the Paris Museum and a fragment and photograph brought to the U. S. National Herbarium in 1922 by Mrs. Chase, the genus remained unknown from 1877 to 1954, when I collected it at three stations in the Sierra de Guadalcázar, between Charco Blanco, Aguaje de Garcia and the Minas de San Rafael (Figs. 18, 19), on Cretaceous limestone outcrops.

The original description of the genus by Fournier (1877) was very brief, as follows [translated]:

> Glumes subequal, the lower shorter; flowers 3, of which 2 are pilose around the base, the summit less so; lemma 5-lobed, lateral and intermediate lobes subulate, palea 2-toothed, panicle ovate, influorescence 4–5 spicate.
>
> The glumes of this genus have the same structure as several of those in the Chlorideae, notably those of the section *Heterostega* of the genus *Atheropogon*, but the location of the lemma with respect to the rachis removes the genus from the Chlorideae. The hairs of the rachis and its appearance, suggests *Calamagrostis*, among [the species of] which one would, at first view, try to place *Calamochloa filifolia*.

The short description of the genus, quoted in the second and third paragraph, was used again by Fournier (1886). In this work he described *C. filifolia* as follows [translated]:

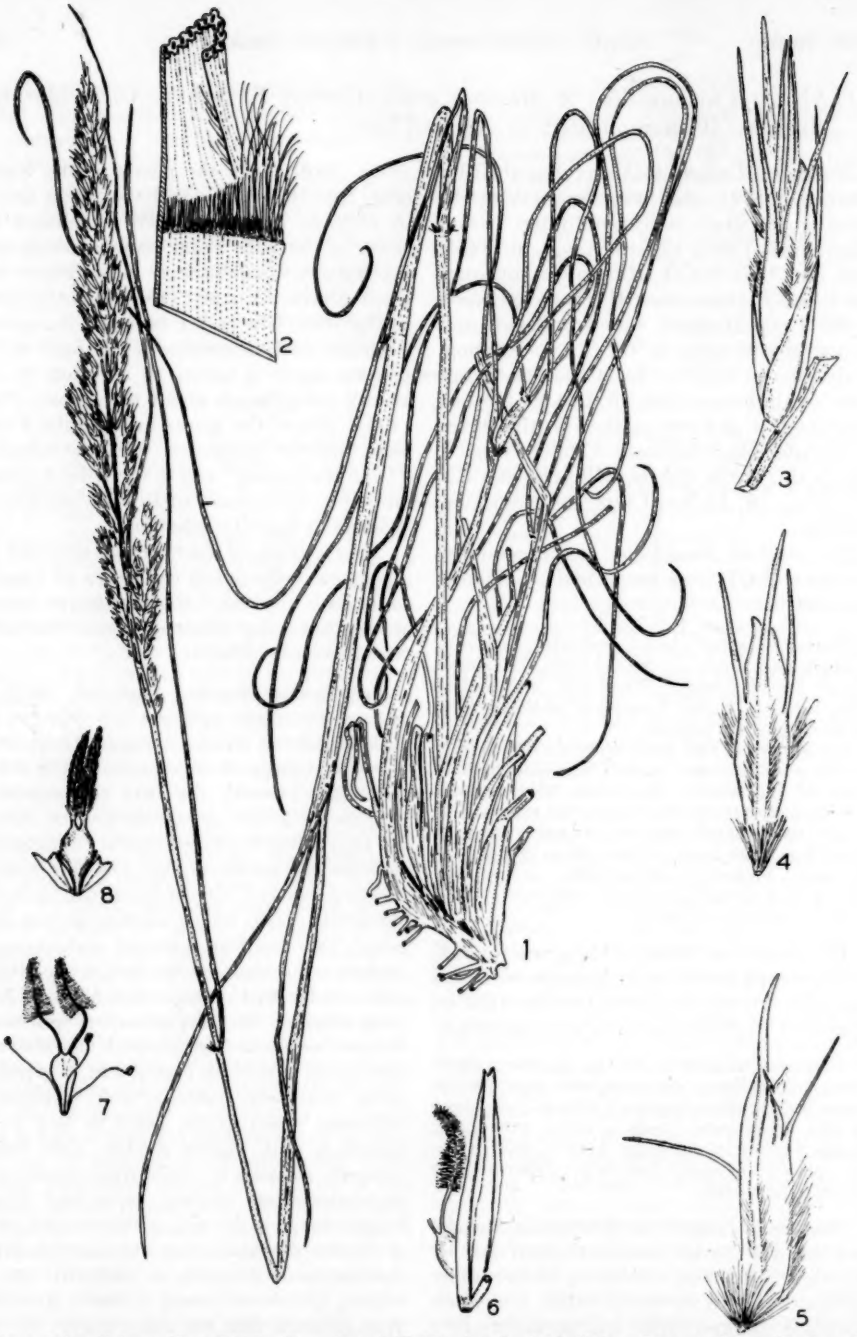
> Culms strict, sheaths striate, glabrous; ligule pilose; blades linear, glaucous, convolute; panicle ovate and terminal; glumes subequal, the upper broadly mucronate, median nerve prominent; lemma 5-lobed [as in] *Polyschistidis*, palea truncate, plicate, obscurely 2-dentate, ⅓ shorter, base and margin villous.

The rather inadequate description and the fact that the species was represented only by the type specimen, consisting of the upper portions of two or three culms and their pistillate inflorescences, led to uncertainty about the genus and its tribal affiliation. Hackel (1887, 1890) put the genus in the tribe Festuceae, subtribe Pappophoreae. Bews (1929) keys the genus in the Festuceae, lists the author and the single species in Mexico. Rozhevits (1937) included the genus in the tribe Pappophoreae along with *Scleropogon*, *Cathestecum*, *Enneapogon* and other genera. Conzatti (1946) put the genus in the tribe Chlorideae between the genera *Tripogon* and *Leptochloa*. The origin of the generic name is given in addition to the known information about the genus. Pilger (1954) placed the genus in the tribe Festuceae, subtribe Festucinae with the notation, "Doubtful genus," and in the tribe Aveneae, subtribe Aveninae with the statement: "Genus of doubtful position."

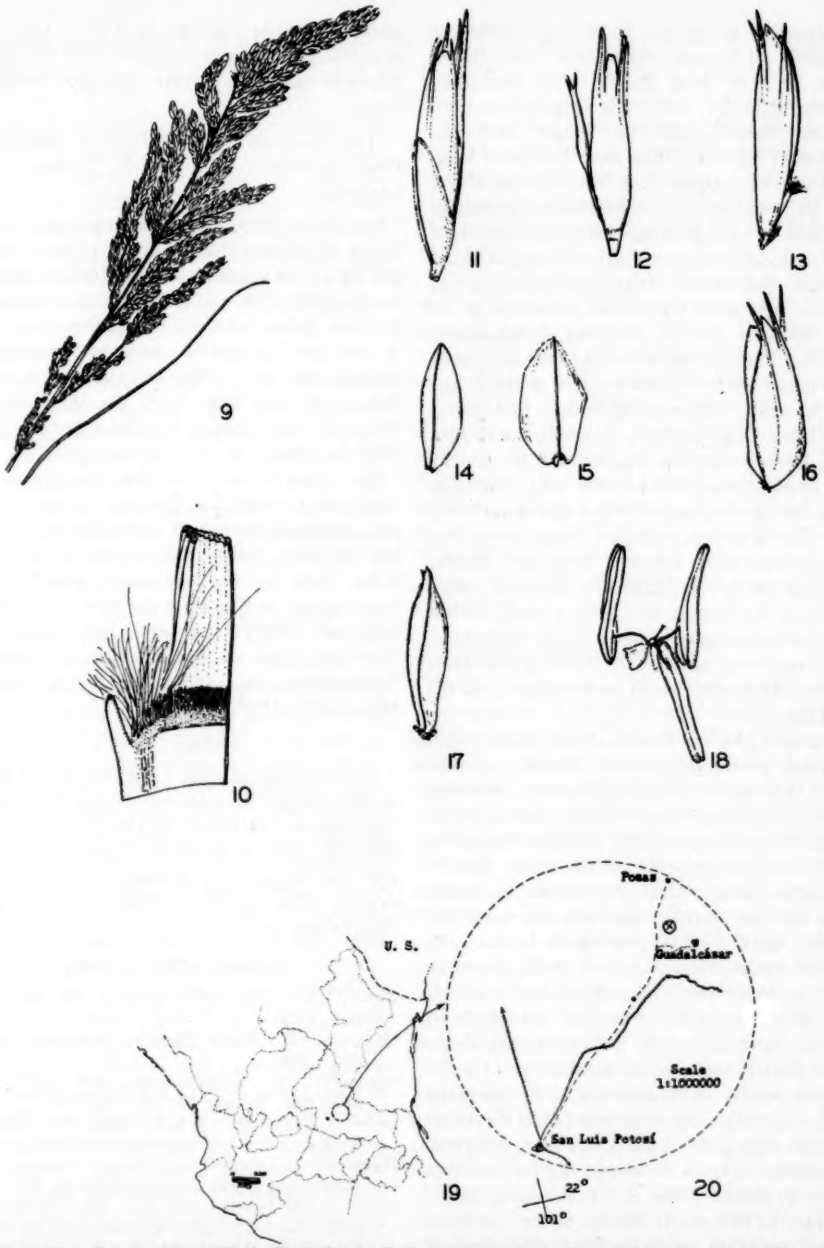
After a study of the type material and the specimens collected in the Sierra de Guadalcázar, it is concluded that the genus belongs in the tribe Pappophoreae (Rozhevits (1937) and Hubbard (1934)).

Calamochloa Fournier—Emended. Plants dioecious. Staminate spikelets 3–5 flowered, the rachilla glabrous and not disarticulating between the florets; glumes about equal in length, 2.8–4.1 mm long, 3-awned, the awns short; palea as long as the lemma or slightly shorter; stamens 3, large, well-developed; pistil rudimentary; lodicules 2, membranaceous. Pistillate spikelets mostly 3-flowered; rachilla disarticulating tardily, the florets usually falling together; glumes about equal, 3.5–7 mm long, 1-nerved, glabrous except slightly scaberulous on the keel toward the tip and over the back; lemma (first floret) to 7 mm long, pilose on the margins and on each side of the median nerve from about 1 mm above the base to the base of the central awn, 3-awned, the awns prominent, subulate and diverging at maturity; callus pilose; palea as long as the lemma or very slightly shorter; pistil well-developed; stamens 3, rudimentary; lodicules 2, membranaceous. Tufted perennials forming tough clumps in dry soil, with long, flat blades which become flexuous and involute on drying. Inflorescences spreading in anthesis, later becoming narrow and compact. Name presumably from *kalamos*, cane and *chloa*, grass.

Calamochloa filifolia Fournier—Emended. Staminate plants: Perennial, densely tufted, the old bases persistent, 30–100 cm tall; culms from



FIGS. 1–8.—*Calamochloa filifolia* Fournier: *1*, Habit sketch of pistillate plant, × ½; *2*, ligule, with portion of blade and sheath (median longitudinal section); *3*, spikelet (from type specimen, Virlet, no. 1461); *4*, lower floret (from type specimen, Virlet, no. 1461); *5*, lower floret; *6*, palea with rachilla joint and pistil; *7*, pistil and stamens of lower floret; *8*, pistil, stamens and lodicules of second floret. (Figs. 2–8, × 7; all figures, except 3 and 4, drawn from Sohns, nos. 1352 and 1506.)



FIGS. 9–20.—*Calamochloa filifolia* Fournier: *9*, Inflorescence of staminate plant, × ½; *10*, ligule with portion of blade and sheath (median longitudinal section); *11*, spikelet; *12*, second and third florets; *13*, first floret with rachilla joint; *14*, first glume; *15*, second glume; *16*, lemma of first floret; *17*, palea; *18*, stamens, rudimentary pistil and lodicules of first floret; *19*, outline map of northern Mexico; *20*, approximate locality of *C. filifolia* (marked by an "x" in a circle). (Figs. 10–18, × 7; drawn from Sohns, no. 1406; fig. 20 based on 1938 edition of a map of the State of San Luis Potosí prepared by the Dirección de Geografía Meterología e Hidrología, Mexico.)

slightly short pubescent to densely pubescent and short appressed pilose below the nodes; blades 10–36 cm long, flat in living specimens, involute when dry, antrorsely scabrous on both surfaces; sheaths glabrous, longer than the internodes; ligule a ciliate rim, 0.7–1 mm long, pilose on the margins near the junction of the blade and sheath, auricles sometimes present as a straight upward prolongation of the margin of the sheath; inflorescence 7–20 cm long, axis and branches pubescent, branches spreading in anthesis, contracted later, short pubescent in the axils; spikelets 5 to 9 mm long, 3–5-flowered, spreading slightly at maturity; rachilla joints short pilose below the floret (base of callus and rachilla joint), otherwise glabrous; first glume 2.8–3.4 mm long, glabrous, 1-nerved, the median nerve often projecting beyond the tip 0.1–0.2 mm; second glume 2.8–4.1 mm long, otherwise as the first glume; lemma of the first floret 5–5.5 mm long, glabrous, 3-awned from below the summit, the awns 1–2 mm long and slightly exceeding the lemma, antrorsely scabrous; palea as long as the lemma or slighty shorter, with a slight membranous wing on each keel; lodicules 2, membranaceous; stamens 3, pollen grains large and well-developed; pistil rudimentary, 0.2–0.5 mm long.

Pistillate plants: Perennial, cespitose, forming hard persistent clumps, 40–100 cm tall; blades 18 to 40 cm long, flat, flexuous, becoming involute and curled when dry, antrorsely scabrous on both surfaces; culms finely pubescent and short appressed-pilose, especially at the nodes; sheaths glabrescent, longer than the internodes, sometimes with an auricle, especially on the lower sheaths; ligule a ciliate rim 0.8 to 1 mm long; hairs abundant at the margins of the ligule on the collar, up to 2.5 mm long; inflorescence 8–21 cm long, axis pubescent, branches spreading at anthesis, later appressed, pubescent and short-pilose; panicle branches short-pilose in the axils; spikelets mostly 10–12 mm long, 3-flowered, the uppermost rudimentary; rachilla joints short and glabrous; first glume 3.5–6.5 mm long, 1-nerved, scaberulous on the keel toward the tip and over the back; second glume 4.7–7 mm long, otherwise like the first glume; lemma of the first floret about 7 mm long, pilose on the margins and on each side of the median nerve from about 1 mm above the base to the base of the diverging central awn; 3-awned, the awns subulate, antrorsely scabrous and diverging at maturity; palea as long as or slightly shorter than the lemma; lodicules 2, membranaceous; stamens 3, 0.2–0.3 mm long apparently non-functional; pistil well-developed; stigmata plumose. Mature caryopses were not found.

The emended description is based on these specimens in the U. S. National Herbarium:

San Luis Potosí (staminate plants): In the Sierra de Guadalcázar between Charco Blanco and Aguaje de Garcia; alt. 1100–1600 m; September 20, 1954, *Sohns* 1340 and 1352a; September 24, 1954, *Sohns* 1460a. On the northeastern slopes of hills near Aguaje de Garcia in the Sierra de Guadalcázar; alt. 1800 m; October 1, 1954, *Sohns* 1487 and 1498. Near the Minas de San Rafael in the Sierra de Guadalcázar; alt. 1900–2100 m; October 3, 1954, *Sohns* 1506a.

San Luis Potosí (pistillate plants): In the Sierra de Guadalcázar between Charco Blanco and Aguaje de Garcia; alt. 1100–1600 m; September 20, 1954, *Sohns* 1352; September 24, 1954, *Sohns* 1460. On the northeastern slopes of hills near Aguaje de Garcia in the Sierra de Guadalcázar; alt. 1800 m; October 1, 1954, *Sohns* 1488. Near the Minas de San Rafael in the Sierra de Guadalcázar; alt. 1900–2100 m; October 3, 1954, *Sohns* 1506.

SUMMARY

Calamochloa filifolia Fournier, a rare genus of one species is redescribed and illustrated. The species, collected in the Sierra de Guadalcázar after a lapse of 77 years, is dioecious and apparently a highly restricted endemic. The genus belongs in the tribe Pappophoreae.

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BOTANY.—*Studies of South American plants, XVI.* A. C. SMITH, U. S. National Museum.

A recent collection of plants made in Peru and Ecuador by Dr. Werner Rauh, Botanisches Institut, Heidelberg, and his associate Dr. Gerhard Hirsch, has disclosed three species of the family Vacciniaceae not previously described. The material upon which the following descriptions are based is deposited in the U. S. National Herbarium.

Sphyrosperum venustum, sp. nov.

Frutex gracilis terrestris ad 50 cm altus, ramulis glabris elongatis 1.5–3 mm diametro basis versus foliorum valde confertorum conspicue incrassatis; stipulis pro genere egregiis binis intrapetiolaribus filiformibus 2–4 mm longis mox caducis; petiolis inconspicuis haud 1 mm longis canaliculatis glabris; laminis in sicco papyraceis fusco-viridibus forsan in vivo carnosis, ellipticoobovatis, 12–16 mm longis, 4–7 mm latis, basi obtusis, apice rotundatis, margine incrassatis leviter recurvatis, juventute ubique minute puberulis mox glabratis, costa et nervis in sicco utrinque paullo elevatis inconspicuis, nervis secundariis utrinsecus saepe 3 adscendentibus, rete venularum obscuro immerso; inflorescentia axillari 1-flora quam foliis breviore, rhachi subnulla, bracteis sub floribus paucis, 2 intimis lanceolatis circiter 1 mm longis acutis obscure ciliolatis, pedicellis haud 0.5 mm longis superne incrassatis apicem versus obscure glanduloso-pilosis (pilis fuscis ad 0.2 mm longis); calyce pilis paucis obscuris limbo et loborum margine exceptis glabro sub anthesi circiter 3 mm longo et 2 mm diametro, tubo cupuliformi obscure 10-gono circiter 1 × 1 mm limbo suberecto papyraceo 5-lobato, lobis deltoideis acutis circiter 1 mm longis et latis, sinibus rotundatis; disco annulari-pulvinato glabro; corolla glabra tenuiter carnosa cylindrico-urceolata sub anthesi circiter 8 mm longa et medium versus 3 mm diametro, basi valde contracta, lobis 5 deltoideis acutis circiter 1 mm longis; staminibus 5 quam corolla paullo brevioribus, filamentis ligulatis circiter 2.5 mm longis supra medium gradatim angustatis et superne intus minute pilosis, extus glabris, antheris circiter 4.8 mm longis; thecis longitudine tubulos subaequentibus basi rotundatis, tubulis gracilibus per rimas ovales circiter 1 mm longas dehiscentibus; stylo gracili corollam fere aequante, stigmate minuto.

Type in the U. S. National Herbarium, no. 2180834, collected between Chimborazo and Guaranda, Province of Bolívar, Ecuador, alt. 3,000 m, in upper zone of the "ceja de la montaña," September 20, 1954, by W. Rauh & G. Hirsch (no. 388).

The graceful species here described is remarkably isolated, but *Sphyrospermum* seems to be the best generic position for it. The crowded leaves, the branchlets conspicuously swollen at the leaf bases, and the peculiar filiform stipules are striking characteristics. The small, elliptic-obovate, rounded leaf blades and the solitary subsessile flowers with only five stamens further separate the new species from its congeners. The reduced number of stamens occurs elsewhere in *Sphyrospermum*, as well as in the related genera *Themistoclesia* and *Eleutherostemon*, but no species with this character are suggestive of *S. venustum*.

Ceratostema callistum, sp. nov.

Frutex epiphyticus 30–50 cm altus, ramis tubere magno ad 20 cm diametro enatis, ramulis subteretibus copiose canescente-hispidulis (pilis gracilibus 1–2 mm longis eglandulosis ad apices ramulorum cum pilis graciliter clavatis glandulosis aequilongis intermixtis); stipulis intrapetiolaribus binis e basi incrassata subulatis 3–5 mm longis ut ramulis hispidulis; petiolis incrassatis rugulosis 4–5 mm longis pariter hispidulis; foliorum laminis subcoriaceis in sicco brunneo-viridibus ovatis, 6–9 cm longis, 3.5–5 cm latis, basi cordatis, in acuminem callosum 1–1.5 cm. longum gradatim angustatis, margine planis paullo incrassatis, supra molliter pilosis (pilis haud 0.3 mm longis) ac etiam parciore glanduloso-pilosis (pilis ad 0.8 mm longis) demum glabrescentibus, subtus pariter pilosis sed pilis longioribus (ad 1 mm) et persistentibus, pinnatinerviis, costa supra leviter impressa subtus elevata, nervis lateralibus utrinsecus plerumque 3 inconspicuis curvatis subplanis, nervis intimis cum costa 1–2 cm concurrentibus, rete venularum immerso; inflorescentiis apices ramulorum versus axillaribus racemosis ut videtur 4–8-floris breviter pedunculatis, rhachi pedicellisque pilis debilibus pallidis 0.4–0.8 mm longis molliter pubescentibus ac etiam pilis anguste clavatis glandulosis aequi-

longis parciore ornatis, rhachi subtereti ad 5 cm longa; bracteis sub floribus papyraceis lanceolatis 5–8 mm longus extus ut pedicellis pubescentibus intus glabris, pedicellis sub anthesi 10–18 mm longis cum calyce articulatis medium versus bibracteolatis, bracteolis bracteis similibus; calyce sub anthesi 22–25 mm longo apice circiter 15 mm diametro ubique ut pedicellis glanduloso- et eglanduloso-pilosis sed pilis brevioribus, tubo cupiliformi circiter 5 mm longo et diametro, limbo suberecto papyraceo reticulato-nervato profunde 5-lobato, lobis lanceolatis 14–17 mm longis; disco cupuliformi glabro crenulato-marginato; corolla tenuiter carnosa cylindrica circiter 45 mm longa et basim versus 6 mm diametro, superne paullo angustata, extus ut calyce molliter pilosa sed tantum superne glandulosa, intus glabra, profunde 5-lobata, lobis subulato-lanceolatis circiter 10–12 mm longis; staminibus 10 sub anthesi leviter exsertis, filamentis membranaceis glabris circiter 7 mm longis in tubum cohaerentibus, antheris circiter 40 mm longis thecis conspicue granulatis circiter 11 mm longis basi mucronulatis et incurvatis, tubulis circiter 29 mm longis gracillimis (superne haud 0.15 mm diametro) per poros ovales subapicales circiter 1 mm longos dehiscentibus; stylo filiformi leviter exserto, stigmate minuto.

Type in the U. S. National Herbarium, no. 2180858, collected near the Hacienda Taulis, near Chiclayo, Valle Río Saña, Department of Lambayeque, Peru, alt. 2,500 m, October 13, 1954, by W. Rauh & G. Hirsch (no. 2186).

Dr. Rauh states that there is a beautiful forest composed chiefly of *Podocarpus* near the Hacienda Taulis, this being the only substantial wooded section in the entire region. The new species is a frequent epiphyte here, its branches arising from a large tuber up to 20 cm in diameter. The corolla is said to be carmine-red without and greenish within.

This very distinct species of *Ceratostema*, compared with my recent key to the 16 known species (in Mem. New York Bot. Gard. **8**: 57. 1952), is seen to be closely related only to *C. peruvianum* Gmel. and *C. pensile* (A. C. Sm.) A. C. Sm., from both of which it is at once distinguished by its narrowly lanceolate calyx lobes. From *C. peruvianum* the new species further differs in its more copious and often glandular indument, its less deeply cordate leaf blades, which are acuminate rather than obtuse at apex, and in its terete rather than costate calyx tube. Our plant is obviously distinct from *C. pensile* in its more copious foliar indument and in its narrowly lanceolate rather than broadly ovate inflorescence bracts and bracteoles.

Ceratostema callistum is the only species of the genus positively known to occur in Peru, although it is probable that some of the Ecuadorian species actually extend southward.

Thibaudia rauhii, sp. nov.

Frutex 0.3–1 m altus ut videtur epiphyticus et tubere magno enatus, ramulis subteretibus gracilibus apices versus 1.5–2 mm diametro, partibus juvenilibus copiose pilosis (pilis albidis circiter 1 mm longis) mox glabrescentibus; stipulis intrapetiolaribus subulatis circiter 2 mm longis pilosis evanescentibus; petiolis leviter canaliculatis 3–3.5 mm longis ut ramulis pubescentibus, laminis subcoriaceis in sicco viridibus oblongo-ovatis, 3–4 cm longis 1.3–1.7 cm latis, basi anguste rotundatis, apice obtusis, margine integris anguste recurvatis, utrinque molliter pilosis (pilis albis 0.3–0.8 mm longis supra evanescentibus subtus persistentibus) ac etiam subtus parce nigro-glanduloso-pilosis, costa supra leviter impressa subtus prominente, nervis secundariis utrinsecus plerumque 2 adscendentibus utrinque inconspicue elevatis, rete venularum immerso; inflorescentia subfasciculata 2–4-flora pilis albis 0.5–1 mm longis ubique copiose molliter pilosa, basi bracteis paucis deltoideo-lanceolatis ad 3.5 mm longis circumdata; pedicellis teretibus sub anthesi 6–9 mm longis basim versus bibracteolatis, bracteolis lanceolatis circiter 5 mm longis caducis; calyce sub anthesi 7–7.5 mm longo et apice diametro, tubo cupuliformi circiter 3 mm longo et diametro, limbo erecto-patente quam tubo manifeste longiore 5-lobato, lobis late deltoideis circiter 1 mm longis acutis; disco annulari-pulvinato glabro; corolla rubra tenuiter carnosa subcylindrica sub anthesi 15–16 mm. longa et medium versus circiter 6 mm diametro, extus praeter basim versus copiose pilosa, intus glabra, lobis breviter deltoideis obtusis; staminibus 10 circiter 10 mm longis, filamentis glabris in tubum circiter 3 mm longum laxe connatis, antheris circiter 8 mm longis, loculis basi incurvatis, tubulis gracilibus 2.5–3 mm longis (quam thecis brevioribus), rimis elongatis; stylo quam corolla breviore, stigmate parvo peltato.

Type in the U. S. National Herbarium, no. 2180848, collected in the valley of the Río

Marcapata, near Cuzco, Department of Cuzco, Peru, alt. 2,800 m, May 22, 1954, in "ceja de la montaña," by W. Rauh & G. Hirsch (no. 1329).

The new species is closely related only to *T. regularis* A. C. Sm., of southern Peru, and *T. densiflora* (Herzog) A. C. Sm., of Bolivia. It differs from both of these in its somewhat smaller and inconspicuously nerved leaf blades, which are rounded at base and obtuse at apex, and in its subfasciculate few-flowered inflorescences, with short pedicels, comparatively large and copiously pilose corollas, and longer stamens.

NOTES AND NEWS

ROGER G. BATES RECEIVES HILLEBRAND AWARD

The 1955 Hillebrand Award was given to Roger G. Bates (WAS), of the National Bureau of Standards. The citation is for his studies of the thermodynamic properties of electrolytic solutions and standardization of the pH scale.

The Hillebrand Award was established in 1925 in honor of William F. Hillebrand, chief chemist of the National Bureau of Standards from 1908 to 1925. Dr. Hillebrand was an authority on analytical chemistry and famous for the development of systematic methods for the complete analysis of rocks and ores. The award is made each year to a member of the Chemical Society of Washington who has made a notable and original contribution to chemistry during the preceding five years.

FURTHER NOTES ON TEACHER TRAINING

A new and unique program to assist secondary schools in science teaching has been announced by the Oak Ridge Institute of Nuclear Studies, Oak Ridge, Tenn. The program, which is jointly sponsored by the National Science Foundation and the U. S. Atomic Energy Commission, and administered by the Institute, will enable a selected group of high-school teachers to undergo a three-month course of training in Oak Ridge and then spend nine months in traveling about the country giving lecture demonstrations in science classes at individual high schools. The results of this experiment will be used by the NSF for program planning and for considering future support of this method of attack on increasing the number of highly able young people in science and engineering.

The program is the latest of several developed by ORINS to stimulate interest in science and science education as a means to help in meeting the steadily increasing demand for scientifically trained personnel in all fields of research and development. The Institute is a nonprofit educational corporation owned by 34 Southern universities, operating under direct contract with the AEC.

The new teaching program, which is administered by the ORINS University Relations Division, will operate generally as follows:

A group of eight to ten secondary-school science teachers will be selected on a national basis by ORINS with the recommendation and advice of a selection committee which will include, among others, high-school teachers and administrators. Beginning with the summer of this year, this group will receive leaves of absence from their respective schools for the academic year only, returning to their normal teaching positions in September of 1957.

The Oak Ridge program will begin with the group's participation in a four-week institute to be held at the ORINS Special Training Division in Oak Ridge. This institute, similar to one held in the summer of 1955 under NSF sponsorship, is designed to provide its participants with up-to-date reviews of scientific developments, classical and modern, stressing that science should be taught as a whole, rather than as a series of highly specialized and unrelated technologies. Both lecture and laboratory work will be included in the curriculum; the topics to be covered include classical and modern physics, chemistry, matehmatics, engineering, science experiments, science-teaching methods, and radioisotope techniques. A number of outstanding authorities in various fields of physical science will assist the ORINS staff in presenting the institute, which will include other secondary-school science teachers, to bring the total enrollment to 48.

During the four weeks following the institute, which will end early in July, the selected group will participate in a program designed to acquaint its members with modern laboratory techniques and experiments. This period will include visits to specific laboratories, work with demonstration equipment, supervised self-training, and some practice teaching.

The third phase of the program will send the teachers "on the road." Each one will be provided with a station wagon and demonstration equipment consisting of easily transportable classroom aids in physics and chemistry. Until the end of May 1957 the teachers will spend their working days visiting high schools in the areas assigned to them, giving classroom demonstration lectures at the sophomore-junior level. It is anticipated that each teacher will spend one week at a single high school, where he may give two to three lectures per day three to five days during the school week. The teacher might also be available for consultation with other science teachers or school administrators.

It is estimated that the total number of high schools reached by this program in one academic year will be between 200 and 250.

A particularly pleasant feature of the program will be the assignment of each teacher to a district where he may use his home town as a base of operations, thus enabling him to spend his week ends and possibly many evenings with his family. The touring portion of the program will end late in May 1957. From then until June 15, the teachers will prepare individual reports on the program and will participate in an evaluation study. It is also planned that, at the conclusion of the program, the demonstration equipment will be presented to the science departments of the high schools whose representatives participated in the program.

During the academic year, the touring teachers will receive a stipend at least equal to their regular teaching salaries. In addition, it is planned to provide a travel allowance to cover expenses while the various schools are being visited. The stipends and travel expenses will be paid by the NSF.

The traveling-teacher program, in common with other programs of the Oak Ridge Institute of Nuclear Studies, is designed to help overcome the distressing disparity between the nation's need for well-trained science teachers and scientifically trained personnel and the present and future supply of such personnel as indicated by enrolments in science courses in our universities, colleges, and secondary schools. The urgent need for implementing our present science-education programs has been strongly stressed in recent speeches by Lewis L. Strauss, chairman of the U. S. Atomic Energy Commission, Dr. Alan T. Waterman, director of the National Science Foundation, and other outstanding leaders in research and education. It is hoped that the new program will act as an educational "chain reaction" to stimulate interest in all phases of science on the part of our nation's high-school students, and at the same time provide an ever-increasing supply of science teachers capable of supplying up-to-the-minute information in science to their pupils.

It is also true that man sees more of the things themselves when he sees more of their origin; for their origin is a part of them and indeed the most important part of them. Thus they become more extraordinary by being explained. He has more wonder at them but less fear of them; for a thing is really wonderful when it is significant and not when it is insignificant.—G. K. CHESTERTON, *St. Francis of Assisi.*

ZOOLOGY.—*A new crayfish of the genus* Procambarus *from South Carolina (Decapoda: Astacidae).* HORTON H. HOBBS, Jr., Samuel Miller Biological Laboratories, University of Virginia. (Communicated by Fenner A. Chace, Jr.)

The first specimen of the species described here was collected on February 4, 1934, by L. M. Mace from near Barnwell, Barnwell County, S. C. Since that time a number of attempts have been made to secure a series of specimens on which to base the description of the species as well as to ascertain the extent of its range. These attempts have met with only slight success, for at the present there are but 118 specimens available from seven localities. On the basis of these collections it may be said that *Procambarus echinatus* occurs in the Salkehatchie River and in the headwater streams of the Edisto River in Bamberg, Barnwell, and Aiken Counties, S. C.

The closest relative of *Procambarus echinatus* appears to be *Procambarus dupratzi* Penn (1953: 1), which is reported to occur in eastern Texas and western Louisiana. These occupy, respectively, the most eastern and western limits of the range of the Spiculifer Group, and with *Procambarus natchitochae* Penn (1953: 5), the range of which appears to be confined to southern Arkansas and northern Louisiana, probably represent more nearly the ancestral stock of the group than do the remaining species. Consequently, it appears that the more "primitive" members are occupying the periphery of the range of the group.

Because at present Dr. George H. Penn is conducting a study of speciation in the Spiculifer Group, no attempt is made to summarize the ranges of the other species: *P. spiculifer* (LeConte, 1856: 401), *P. versutus* (Hagen, 1870: 51), *P. vioscai* Penn (1946: 27), *P. penni* Hobbs (1951: 273), *P. suttkusi* Hobbs (1953a: 173), and *P. raneyi* Hobbs (1953b: 412).

I wish to acknowledge with thanks the kindness of Dr. Penn in lending me two lots of specimens from the Tulane Collection and of Dr. G. Robert Lunz, Jr., formerly of the Charleston Museum, who lent me the first specimen of this new species I had seen. Also I express my appreciation to the following who have aided me in securing specimens of this new species: Dr. R. D. Suttkus, Dr. W. R. West, E. A. Crawford, and T. R. Bello.

Procambarus echinatus,[1] n. sp.

Diagnosis.—Rostrum with lateral spines; acumen spiculiform and constituting 41.6–52.0 percent of the total length of the rostrum; postorbital ridges terminating in spines; suborbital angle absent; lateral surface of carapace with two or more spines present just caudad to cervical groove; areola 2.5–4.2 times longer than broad and constituting 21.3–27.4 percent of entire length of carapace. Simple hooks present on ischiopodites of third and fourth pereiopods that extend proximad of distal end of respective basipodites, neither of the latter of which bears an opposable tubercle. First pleopod of first form male (Figs. 1, 5) terminating in four parts: mesial process subspiculiform with only the tip corneous; cephalic process corneous, slender and lying laterad of the central projection; caudal element represented by a truncate poorly defined caudal knob from which arises the subacute, scalelike, corneous caudal process; central projection, the most conspicuous of the terminal elements corneous, subacute and directed at an angle of about 70° to the main shaft of the appendage. Annulus ventralis (Fig. 12), slightly movable and partially concealed by the underhanging multituberculate sternum lying immediately cephalad of it, more than twice as long as broad; a transverse cephalically situated ridge is interrupted by a longitudinal median furrow which continues caudally as the sinuous sinus almost to the midcaudal margin of the annulus; the fossa lies near the median line immediately caudad of the transverse ridge.

Holotypic male, form I.—Body subovate, slightly compressed laterally; abdomen shorter than carapace (59.2–64.0 mm). Height and width of carapace subequal in region of caudodorsal margin of cervical groove (30.0–29.5 mm).

Areola relatively broad and short, about 4.2 times as long as wide with nine fine punctations

[1] *Echinatus*, Latin, set with prickles, prickly. Chosen because of the well-developed spines on the carapace and cheliped of this species.

in narrowest part. Cephalic section of carapace about 2.5 times as long as areola (length of areola about 28.3 percent of entire length of carapace).

Rostrum long with acumen extending beyond peduncle of antennule, excavate; sides convex and terminating at base of acumen in acute cephalolaterally directed spines. Acumen longer than half the remainder of rostrum (10.1 mm). Margins of rostrum not swollen or conspicuously elevated. Upper surface with a few minute punctations. Subrostral ridges poorly developed and not evident in dorsal aspect.

Postorbital ridges prominent, tuberculate, grooved dorsolaterad, and terminating cephalad in acute spines. Suborbital angle absent; branchiostegal spine well developed. Each side of carapace with a row of seven to nine tubercles and spines immediately caudad of cervical groove; upper surface of carapace punctate and lateral surface very strongly granulate.

Cephalic section of telson with two spines in each caudolateral corner. Epistome with a small cephalomedian spine (see fig. 3).

Antennules of the usual form with a strong acute spine present on ventral side of basal segment.

Antennae broken (see description of allotype and morphotype). Antennal scale long, moderately broad; widest slightly proximad of midlength; outer distal margin with a moderately strong spine.

Chela somewhat depressed with the palm somewhat inflated; outer margin of hand slightly concave at base of immovable finger. Hand entirely tuberculate. Inner margin of palm with a row of eight tubercles; a row of four tubercles immediately above this row and a single tubercle below it near distal end; a moderately prominent knoblike tubercle present on lower surface of palm at base of dactyl. Opposable margin of dactyl with a row of 20 knoblike tubercles, fourth from base largest but not forming a distinct emargination; upper surface of dactyl with no distinct longitudinal ridge but with tubercles proximad and setiferous punctations distad; mesial margin of dactyl with a row of 10 tubercles that diminish in size distally; lower surface of dactyl similar to upper surface. Opposable margin of immovable finger deeply concave with an upper row of 19 tubercles, the fifth from base largest, and a distal lower row of six of which the second from base is largest; minute denticles between the tubercles of each row and between the two rows; upper surface of immovable finger with a distinct submedian longitudinal ridge flanked proximally by tubercles and distally by setiferous punctations; lateral surface of immovable finger convex (i.e., distal two-thirds of finger bent mesiad) with tubercles along basal one-third, and distal two thirds with a row of setiferous punctations; lower surface of finger similar to upper surface.

Carpus of first right pereiopod with a broad longitudinal depression flanked on each side by tubercles in poorly defined rows; submedian furrow interrupted distally by a small tubercle near distal margin of podomere. Mesial surface with one large submedian tubercle with a few smaller ones at base and one large one on upper distal margin; below the large submedian tubercle just mentioned are four somewhat smaller ones; lower distal margin with the usual two large tubercles with a row of three small ones proximad of the more mesial tubercle; lateral surface with punctations and a few scattered tubercles.

Merus of first right pereiopod with a few small tubercles and scattered punctations on lateral surface; upper surface with tubercles along entire length, except near distal extremity, with two of the more distal ones larger than the others; mesial surface with a few tubercles distally and somewhat excavate along middle three-fifths, producing a longitudinal furrow near lower margin. Lower surface with two rows of spikelike tubercles, an outer one of 5 and an inner one of 13; two or three additional small tubercles present between and to the sides of these two rows.

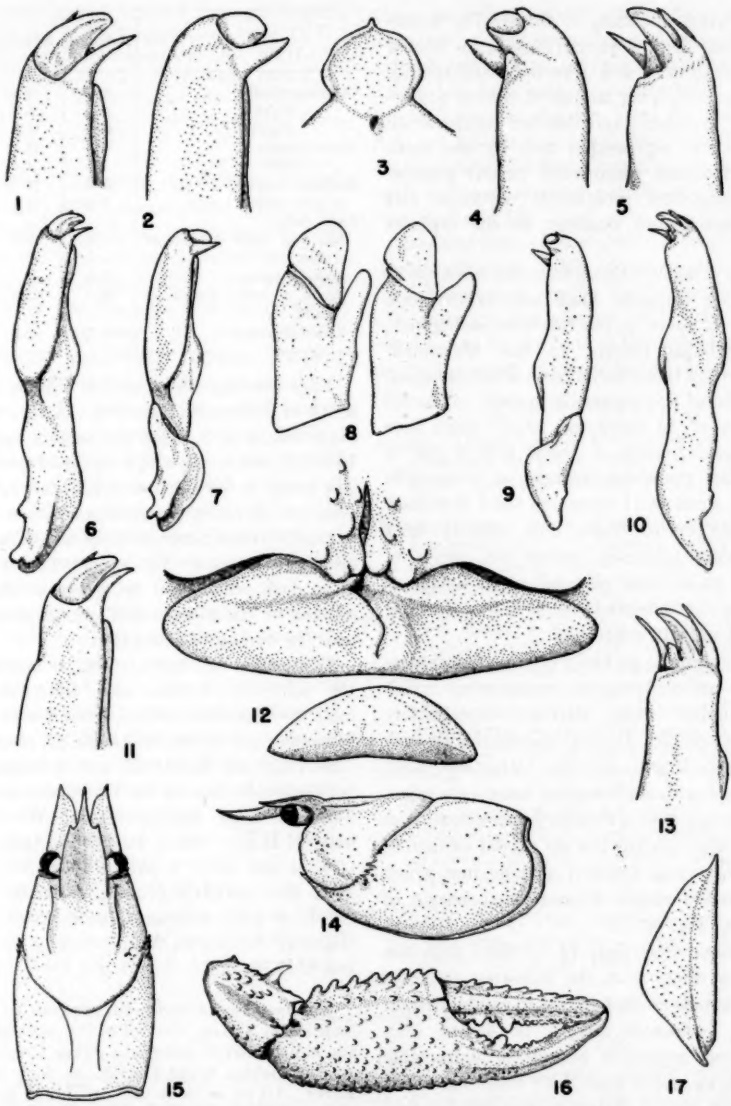
Ischiopodite of first right pereiopod with a row of four tubercles continuing from the lower mesial row on merus.

Basipodite of first right pereiopod without tubercles.

Coxopodite of first right pereiopod with no cephalically projecting spine but with a small caudally projecting one on caudomesial angle.

Hooks present on ischiopodites of third and fourth pereiopods; hooks simple and extend proximad of distal end of their respective basipodites; basipodites bear no opposable tubercles. Coxopodites of fourth and fifth pereiopods with caudomesial projections: that on fourth knoblike, that on fifth more compressed and more sharply defined.

First pleopod reaching coxopodite of third



FIGS. 1–17.—*Procambarus echinatus*, n. sp. (pubescence removed from all structures illustrated): 1, Mesial view of distal portion of first pleopod of holotype; 2, mesial view of distal portion of first pleopod of morphotype; 3, epistome of holotype; 4, lateral view of distal portion of first pleopod of morphotype; 5, lateral view of distal portion of first pleopod of holotype; 6, mesial view of first pleopod of holotype; 7, mesial view of first pleopod of morphotype; 8, basipodites and ischiopodites of third and fourth pereiopods of holotype; 9, lateral view of first pleopod of morphotype; 10, lateral view of first pleopod of holotype; 11, mesial view of distal portion of first pleopod of first form male from Aiken County, S.C.; 12, annulus ventralis of allotype; 13, lateral view of distal portion of first pleopod of first form male from Aiken County, S.C.; 14, lateral view of carapace of holotype; 15, dorsal view of carapace of holotype; 16, distal podomeres of cheliped of holotype; 17, antennal scale of holotype.

pereiopod when abdomen is flexed. Tip terminating in four distinct parts (Figs. 1, 5). Mesial process spiculiform and directed caudodistad. Cephalic process, lying laterad of central projection, acute, corneous, and directed caudodistad. Caudal element represented only by the small corneous, laterally compressed caudal process. Central projection prominent, corneous and directed caudodistad similarly as the cephalic process.

Allotypic female.—Differs from the holotype in the following respects: Each side of carapace with a row of seven or ten tubercles and spines; antenna extends caudad to last abdominal segment; row of tubercles on palm above marginal row consists of six; opposable margin of dactyl with a row of 14 tubercles, fourth from base largest; mesial margin of dactyl with a row of 11 tubercles; opposable margin of immovable finger with a row of 11 tubercles, third from base largest, and entire finger only slightly bent mesiad; fewer tubercles present on carpus of chela but major ones situated as in holotype; mesial row of tubercles on lower surface of merus with only 12 tubercles.

Annulus ventralis partially obscured in ventral aspect by multituberculate prominences which extend caudad from sternum immediately cephalad of annulus. Annulus spindle shaped with the greatest length in the transverse axis; cephalic half with an irregular transverse ridge, and caudal half with a median prominence; sinus originates near median line on caudal surface of cephalic ridge and forms a sinuous line which extends caudad almost to midcaudal margin of annulus (see Fig. 12).

Morphotypic male, form II.—Differs from the holotype or allotype in the following respects: Antenna extends caudad almost to caudal margin of telson; opposable margin of dactyl with 16 tubercles; opposable margin of immovable finger with an upper row of 17 tubercles and a lower distal one of four; ischiopodite of first pereiopod with three or four tubercles; secondary sexual characters as in holotype but much reduced in size.

First pleopod with all processes represented, although none corneous, and while less well defined are all similarly situated as in holotype but directed more caudad (see Figs. 2, 4).

Measurements.—As follows (in millimeters):

	Holotype	Allotype	Morphotype
Carapace—height	30	24.8	25.7
width	29.7	25.2	26.0
length	64.0	54.5	54.9
Areola—length	18.1	14.5	15.0
width	4.3	4.4	4.2
Rostrum—length	22.5	19.2	19.3
width	9.9	8.5	8.5
Right chela—			
length of inner margin of palm	21.4	9.7	13.0
width of palm	21.0	9.7	12.7
length of outer margin of hand	59.5	29.0	37.0
length of dactyl	32.1	16.3	20.7

Type locality.—Salkehatchie River, 1.9 miles south of Barnwell, Barnwell County, S. C., on State Highway 3. Here the stream varies from 10 to 100 feet across with a sand and mud bottom. The water is dark brown, with little silt suspension, and in many places flows with a moderate current through dense growths of *Vallisneria* and *Saururus cernuus*. My specimens were taken after dark resting on eel grass in the swifter reaches of the stream and on submerged roots near the surface of the water.

Disposition of types.—The holotypic male, the allotypic female, and the morphotypic male are deposited in the United States National Museum (nos. 99180, 99181, 99182, respectively). The following paratypes are retained in my personal collection at the University of Virginia: 9-349-7a—type locality (1 ♀), W. R. West and H.H.H., coll.; 4-1955-6a—type locality (1 ♀, 4 juv. ♂♂, 1 juv. ♀), E. A. Crawford, T. R. Bello and H.H.H., coll.; 9-349-6a—Georges Creek, 9 miles southeast of Barnwell on State Highway 64 (1♂II, 3 juv. ♀♀), W. R. West and H.H.H., coll.

Specimens examined.—In addition to the types mentioned above, the following specimens from the Edisto River system in Aiken County, S. C., are available: 6-749-2—trib. s. fork of Edisto River, 11.2 mi. n. of Aiken (1♂II), R. D. Suttkus, coll.; 8-1952-2a—creek, 10.7 mi. n. of Aiken on U. S. Rt. 1 (5♂♂II, 13♀♀, 3 juv. ♂♂, 4 juv. ♀♀), H.H.H., coll.; 4-1955-4a—Bridge Creek, 10.6 mi. n. of Aiken on U. S. Rt. 1 (1♂I, 4♀♀II, 8♀♀, 13 juv. ♂♂, 12 juv. ♀♀), E. A. C., T. R. B., and H. H. H., coll.; 4-1955-5, south fork of Edisto River, 12.3 mi. n. of Aiken on U. S. Rt. 1 (2♀♀, 1 juv. ♂), E.A.C., T.R.B., and H.H.H.; 9-1355-1a, same as preceding (1♂I, 3♀♀II, 3♀♀, 2 juv. ♂♂, 4 juv. ♀♀), H.H.H., coll.; 4-1955-3a—Shaws Creek, 16.1 mi. sw. of Wagener

on St. Rt. 215 (4 juv. ♂♂, 1 juv. ♀) E.A.C., T.R.B., H.H.H., coll.; Tulane University (T.U.) 3311-17.5 mi. s. of Batesburg on St. Rt. 391 (1♂II, 8 juv. ♂♂, 4 juv. ♀♀), G. H. Penn and J. B. Black, coll.; T.U. 3312—5.7 mi. ne. of Aiken on St. Hy. 391 (1♂II, 3♀♀, 1 juv. ♂, 4 juv. ♀♀), G.H.P. and J.B.B., coll.

Color notes.—Carapace olive-green dorsad, fading ventrally into creamy white with ridges edged in black. In addition to the ground color of carapace the cephalic region is marked by a broad distinctly U-shaped black yolk following the contour of the cervical groove; however, base of U not continous but broken between attachments of mandibular muscle. Thoracic portion of carapace with a similarly disposed and broken U-shaped black marking—the broken portion occurring at caudal end of areola. Abdominal segments greenish with caudal portion bright blue bearing reddish-purple and vivid red markings. Chela reddish black with white tubercles; distal portion of fingers red but fading at the extreme distal ends into the yellow corneous spines.

Variations—While there are a considerable number of variations from specimen to specimen, none of these, including ratios of body parts, has been demonstrated to be correlated with any of the several local populations represented. Indeed, there is almost as much variation between individuals collected from the type locality as there are between any one of them and specimens taken elsewhere. Only in the number of spines along the cervical groove and in minor details of the first pleopod of the male may specimens from the Edisto drainage be distinguished from those from the Salkehatchie. Specimens from the latter all have from three to five spines on each side of the carapace, whereas those from the Edisto usually have only two, although as many as four are present on one side of two of the specimens examined. There are so few first form males available, one from the Salkehatchie and two from the Edisto, that it is not known how much variation does exist; for this reason the first pleopod of specimens from both drainage systems are figured (cf. Figs. 1 and 11; 5 and 13).

Relationships.—*Procambarus echinatus* has its closest affinities with *Procambarus dupratzi* (Penn) but may readily be distinguished from the latter by the absence of a carina on the rostrum and by the form of the caudal element of the first pleopod of the first-form male.

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Accurate and minute measurement seems to the non-scientific imagination a less lofty and dignified work than looking for something new. But nearly all the grandest discoveries of science have been but the rewards of accurate measurement and patient long-continued labor in the minute sifting of numerical results.—LORD KELVIN, *Report of the British Association for the Advancement of Science* **41:** 91. 1871.

ZOOLOGY.—*A new entoniscid (Crustacea: Isopoda) from the Pacific coast.* LEONARD MUSCATINE, University of California, Berkeley. (Communicated by Fenner A. Chace, Jr.)

The occurrence on the American west coast of an entoniscid isopod has been recognized for some time, although the only known printed reference is that of Menzies and Miller in Light et al. (1954), p. 141. There they report that "a genus closely related to *Portunion*" is parasitic on *Hemigrapsus oregonensis* in the San Francisco Bay region. On the basis of the systematic arrangement of the 11 known genera of the family which is included in the work of Shiino (1942) on the Entoniscidae of Japan, the form mentioned by Menzies and Miller has been established as a member of the genus *Portunion* and, further, has been found to be an undescribed species. The description below follows the terminology of Shiino throughout.

This problem was suggested to me by Dr. Cadet Hand, of the Department of Zoology, University of California, Berkeley, and I am grateful to him for much kind advice and criticism.

Genus **Portunion** Giard and Bonnier, 1886

Female with two ventral and a pair of antero-dorsal ovarian processes. Marsupium complete; ascendant lamellae of first pair of oöstegites entirely covered by second pair. First four abdominal segments have folded pleural lamellae. Male cephalon fused with, or distinct from, first thoracic segment. Abdomen bears ventromedian hooks. Sixth peraeopod of epicaridium neither prehensile nor longer than others; propodus with simple process at its tip and rudimentary dactylus. (From Shiino.)

Portunion conformis, n. sp.

Female (Fig. 1A, B, E): From hood to tip of posterior medioventral ovarian process ca. 15 mm long; abdomen ca. 8 mm long in the largest specimen. Marsupium, when full of ova, yellowish; full of epicaridian larvae, brown to dark brown; ovary whitish to yellow; abdomen white. Exopodite of maxilliped broad, surface wrinkled, edges frilled and thicker than central portion; coxopodite egg-shaped, smaller than exopodite; endopodite lamellar, lying beneath the coxopodite with medial border exposed. Cephalon a pair of spheres separate from the thorax. Two pairs of antennae inserted on the cephalon dorsal to the maxillipeds in the form of parallel ridges; the external antenna slightly smaller than the internal. Dorsal ovarian processes arise from middle of thorax and incline anteriorly; of the two ventral processes, the anterior is shorter and arises vertically from the thorax, forming a right angle with the posterior which projects backwards except in gravid females where the processes are somewhat displaced. Thorax cylindrical, bearing five pairs of oöstegites (Fig. 1B); first pair inserted under maxillipeds and each divided into ascendant, transverse and recurrent lamellae (Fig. 1E); ascendant lamellae project anteriorly over the cephalon and continuous with the transverse lamellae which curve laterally; both somewhat thickened and supported by a vein at their inner margin; recurrent lamellae extend posteriorly the length of the thorax and curve around the posterior ventral ovarian process; these lamellae relatively thin and supported by a vein running down the center with numerous branches to the outer margins. The second pair of oöstegites curves anteriorly over the cephalon, covering the first pair and forming the hood; members of this pair meet on median ventral line forming a conspicuous inpocketing, but do not fuse. The three remaining pairs of oöstegites inserted laterally on the thorax and closely applied to the host membrane; they overlap medially in young specimens and may overlap one another longitudinally without fusing, thereby remaining easily distinguishable; fifth pair slightly larger than third and fourth owing to an antero-posterior elongation of the distal border. In mature specimens, all oöstegites meet their fellow on the opposite side, enclosing the recurrent lamellae of the first pair, and forming the brood pouch. The lateral protuberances of the thorax are irregularly-shaped bodies which occur in pairs (Fig. 1B); the larger usually spherical while the smaller is curved or peduncular. The second to fifth peraeopoda mentioned by Shiino and earlier authors are difficult to discern in this species.

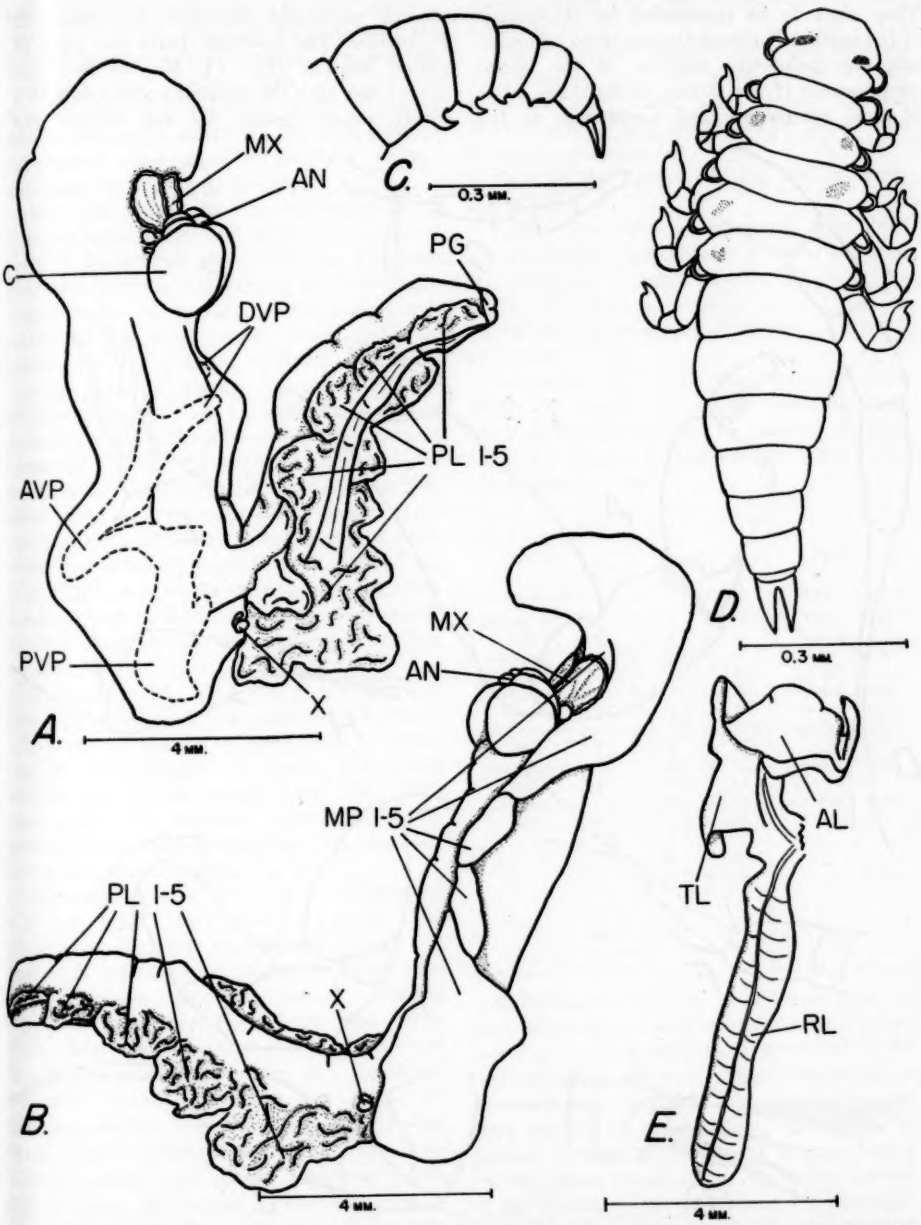

FIG. 1.—*Portunion conformis*, n. sp.: A, ♀ with thorax enclosed in host membrane; B, young ♀ with host membrane removed; C, ♂ abdomen; D, dorsal view of mature ♂; E, oöstegite I. (Abbreviations: *al* ascendant lamella, *an* antenna, *avp* anterior medio-ventral ovarian process, *c* cephalon, *dvp* dorsal ovarian process, *mp* oöstegite, *mx* maxilliped, *pg* pygidium, *pl* pleural lamella, *pvp* posterior medio-ventral ovarian process, *rl* recurrent lamella, *tl* transverse lamella, *x* lateral protuberance of thorax.)

They seem to be represented by thickenings of the anterior border of the last three oöstegites and the peduncular member of the lateral protuberance of the thorax; of these the latter is most conspicuous and corresponds to the seventh peraeopod described by Shiino in *P. flavidus*. The abdomen bears five pairs of pleural lamellae (Fig. 1A, B); the first pair much larger than the remaining pairs and with a highly crispate margin; the rest become pro-

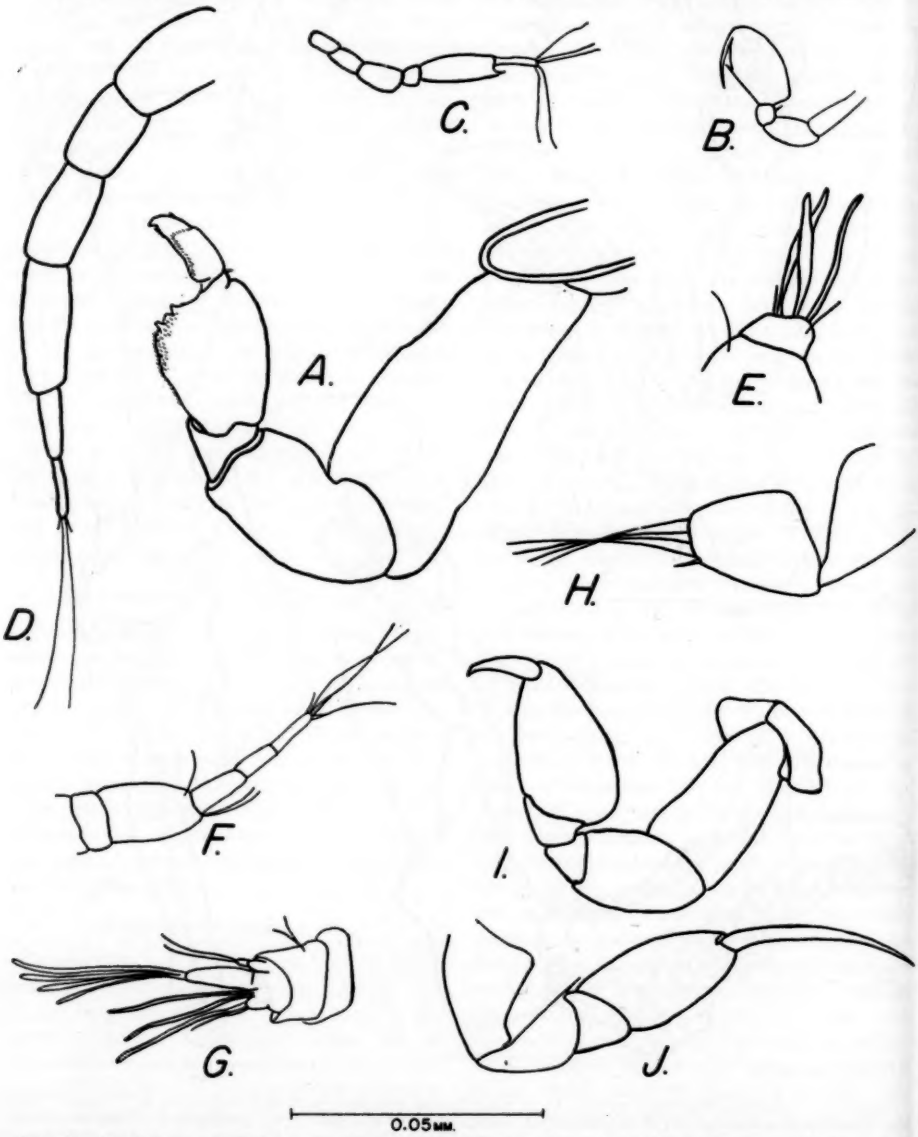

FIG. 2.—*Portunion conformis*, n. sp.: A, ♂ peraeopod IV; B–E, epicaridium (B, paraeopod I; C, peraeopod VI; D, antenna; E, antennule); F–J, cryptoniscium (F, antenna; G, antennule; H, pleopod; I, peraeopod I; J, peraeopod VII).

gressively smaller from front to back and the complexity of the marginal folds lessens; the fifth is a simple triangular lamella. The pleopoda uniramous and overlap their members on opposite sides. The pygidium small, bifurcated and curved slightly ventrally. The third abdominal segment often bulges on its dorsal surface, indicating the position of the heart.

Male (Fig. 1C, D): 1.1 mm long and at fourth thoracic segment 0.3 mm wide with scattered brown to dark brown pigment patches. Cephalon fused with first thoracic segment but distinguishable ventrally and laterally. Antennules rounded bosses bearing many small setae. Antennae absent. Oral cone bears styliform mandibles. Lateral parts of thoracic segments slightly attenuated except last segment which has a truncate margin. Coxal plates well developed and projecting laterally. Peraeopoda 5-jointed; carpopropodus and dactylus clad with rows of spinules; distal margin of carpopropodus bears blunt processes (Fig. 2A). Ventral spines on first three abdominal segments hooklike with pointed tip (Fig. 1C); that of fourth reduced; other segments lacking spines. Bifid ends of last segment straight, inclined ventrally at tips and more or less smooth (Fig. 1C, D).

Epicaridium (Fig. 2B–E): 0.26 mm long and 0.11 mm wide. First five peraeopoda 6-jointed with propodus bearing a short process at lateral end of distal margin and merus with small seta on its external margin (Fig. 2B). Sixth peraeopoda with dactylus straight and surmounted by a crown of long setae; propodus ends in a short pointed process (Fig. 2C).

Cryptoniscium (Fig. 2F–J): 0.5 mm long and 0.16 mm wide. Body wider anteriorly than posteriorly. General pigmentation brown in scattered patches; eye pigments darker than other pigments and well defined. Antenna 6-jointed, basal three parts larger than distal three; third bears three short hairs and sixth ends in a bundle of long hairs (Fig. 2F). Antennule 4-jointed; second joint with short setae on anterior margin; third narrower and bearing three bundles of short hairs, the outer two bundles arising from jointed tubercles; fourth still narrower, surmounted by two rami, each of which ends in long hairs (Fig. 2G). Peraeopoda 6-jointed (Fig. 2I); last peraeopod more slender than others, merus with long spine continuous with its distal margin (Fig. 2J). Exopodite of pleopod bears four long setae and one short seta (Fig. 2H).

Distribution and habitat: Taken from Berkeley Yacht Harbor and Bay Farm Island on San Francisco Bay, Calif., and Drake's Lagoon, Marin County, Calif., where they are parasitic on *Hemigrapsus oregonensis*.

Type locality: Berkeley Yacht Harbor, Berkeley, Calif.

Types: The following specimens have been deposited in the United States National Museum: (1) Holotype, 1 adult female, U.S.N.M. no. 99177; (2) allotype, 1 adult male, U.S.N.M. no. 99178; (3) paratypes, 6 females, U.S.N.M. no. 99179.

Discussion: 372 crabs were examined from which 85 female entoniscids were obtained. These apparently included all stages of development. The frequency of infection is shown in the accompanying table.

	Host	Uninfected	Infected	Total	Percent infected	Locality
August 16	♂	50	4	54	7.4	Berkeley Yacht
1955	♀	8	0	8	0	Harbor
August 23	♂	61	12	73	16.4	Berkeley Yacht
1955	♀	3	1	4	25.0	Harbor
August 31	♂	50	5	55	9.1	Berkeley Yacht
1955	♀	8	1	9	11.1	Harbor
September 6	♂	22	6	28	21.4	Drake's Lagoon
1955	♀	17	2	19	10.5	
November 3	♂	12	12	24	50.0	Berkeley Yacht
1955	♀	1	16	17	94.1	Harbor
December 8	♂	41	12	53	22.6	Bay Farm Island
1955	♀	10	8	18	44.1	
TOTALS	♂	236	51	287	17.7	
	♀	57	28	85	32.9	
	♂ and ♀	293	79	372	21.2	

Simultaneous infection of a single host by more than one parasite occurred often. Where four were found in one host, they were all of the "asticot" stage. In cases where two parasites infected a single host, they were both mature and often gravid. Of the six male entoniscids examined, all were found on the females, either on the pleural lamellae, in the dorsal groove of the thorax, or on the abdomen in the midventral line. In no cases were females accompanied by more than one male. Cryptoniscan larvae occurred frequently on females of all stages.

Unlike such cases as the infection of *Pinnotheres*

		P. maenadis	P. kossmanni	P. flavidus	P. conformis
Female	Ventral processes	Both processes directed backward	Anterior directed forwards, the posterior backward	Anterior vertical to thorax, posterior directed backward	Anterior vertical to thorax, posterior directed backward
Male	Cephalon	Distinct from thorax	Distinct from thorax	Fused with 1st thoracic segment	Fused with 1st thoracic segment
	Antenna	Present	?	Absent	Absent
	Abdominal hooks	In segments I–IV	In segments I–IV	In segments I–II	In segments I–IV
Epicaridium	Dactylus of peraeopod VI	Setose	?	Not setose	Setose

pisum by the entoniscid *Pinnotherion vermiforme* Giard and Bonnier as reported by Atkins (1933), where the thinness of the host's carapace reveals the presence of the parasite, the new species cannot be detected by external signs. The infected hosts appear perfectly normal and the presence of a parasite can only be determined by dissection.

The adult parasite is usually found on its side in the visceral cavity of the host. The body is V-shaped, head and thorax pointing anteriorly forming one arm, and the abdomen the other. The hepatic tissues of the host surround the head and abdomen of the parasite while the junction of thorax and abdomen lies under the alimentary canal.

Of the five species of *Portunion* previously described, *P. moniezii* Giard and *P. salvatoris* Kossman are poorly defined. However, *P. conformis*, the new species, has short, straight, ventral ovarian processes which distinguishes it from *P. salvatoris*. The greatly developed first pair of oöstegites of the new species distinguishes it from *P. moniezii*. It differs from the three remaining species as shown in the table above.

The species *P. flavidus* is commonly found infecting *Pachygrapsus crassipes* in Japan. This crab is a prominent member of the American west coast intertidal fauna and one might expect to find *P. flavidus* here. However, examination of 22 specimens of *P. crassipes* has failed to disclose any entoniscids.

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Experiment is the interpreter of nature. Experiments never deceive. It is our judgment which sometimes deceives itself because it expects results which experiment refuses. We must consult experiment, varying the circumstances, until we have deduced general rules, for experiment alone can furnish reliable rules.—LEONARDO DA VINCI.

ZOOLOGY.—Cossura pygodactylata, *a new annelid from San Francisco Bay (Polychaeta: Cirratulidae)*.

MEREDITH L. JONES, University of California, Berkeley. (Communicated by Fenner A. Chace, Jr.)

In the course of sampling the benthic fauna off Point Richmond, San Francisco Bay, Calif. (Jones, 1954), numerous specimens of a polychaete worm of the family Cirratulidae were found. At the outset they were tentatively identified as *Cossura longocirrata* Webster and Benedict, but subsequent examination revealed characters differing sufficiently from the original description to justify setting up a new species for these worms.

Webster and Benedict (1887) erected the genus *Cossura* for the single species *C. longocirrata* from Eastport, Maine. Of their specimens only one was complete, the remainder apparently being anterior portions. Eliason (1920) found specimens which he tentatively identified as *C. longocirrata* in the Øresund, Denmark. He noted minor differences in the shape of the prostomium and the dimensions of the unpaired cirrus. In the following year, Thulin (1921) confirmed Eliason's identification and gave a detailed description of the species, based on well-preserved specimens from the Øresund. Mrs. E. Wesenburg-Lund (personal communication) has identified *C. longocirrata* in collections from the North Atlantic and from the coast of Chile.

Cossura has been reported from the Pacific coast of North America several times. Hartman (1952) identified *C. longocirrata* in collections from the Los Angeles–Long Beach area, and Reish and Winter (1954) recorded the same species from Alamitos Bay, California. Hartman (1954) in a checklist of the annelids of San Francisco Bay, listed "*Cossura* nr. *longicirrata*" and credited the author (M. J.) with its collection. In the preliminary results of her study of the benthos of the San Pedro Basin, Hartman (1955) reported specimens of *Cossura* sp. and has recently described this as a new species, *Cossura candida* (Hartman, 1955a). It should be noted that in the description of *C. candida*, Hartman has included the "*Cossura* nr. *longicirrata* (sic) . . ." of her San Francisco Bay checklist in the synonymy and distribution record of *C. candida*. Actually "*C.* nr. *longicirrata*" is the species to be described here and *C. candida* is not known to occur in San Francisco Bay.

Family CIRRATULIDAE

Genus **Cossura** Webster and Benedict, 1887

Cossura pygodactylata, n. sp.

Fig. 1, A–F

Cossura longocirrata Jones, 1954, pp. 36, 37, 48, 83, et al.

Cossura nr. *longicirrata* Hartman, 1954, pp. 11, 15.

Cossura nr. *longicirrata* (sic) Hartman, 1955a, pp. 44 and 45 (in synonymy and distribution record of *Cossura candida*).

The specimens under consideration were collected from mud off Point Richmond, San Francisco Bay, Calif., at depths of 3, 5, and 30 feet below mean lower low water, and were most numerous at the lowest depth. Approximately 100 specimens were obtained; of these, 15 were entire, the remainder having fragmented when preserved with 10 percent formalin. Several observations of living, intact animals were also made.

Preserved, whole, mature specimens of *Cossura pygodactylata* are 6 to 7 mm in length and about 0.3 mm wide at the 14th (widest) setiger. The number of segments varies from 43 to 56.

Contrary to the observations of Eliason (1920) and Thulin (1921) on *C. longocirrata*, *C. pygodactylata* appears to secrete no well-defined tube. The living animal secretes mucus along the body, to which material (fecal pellets, debris) may adhere, giving the impression of a very loosely constructed tube.

The body is composed of three general regions. The anterior region extends to the 17th–19th setiger and the segmental length is 80–100 micra; the setae occur in bundles at the anterior edge of each segment. The midregion extends back to about 12–20 segments from the pygidium and segmental length is 280–340 micra; the setae are centrally located on each segment. The posterior region consists of 12–20 segments and the segmental length is 100–120 micra; the setae are centrally placed on each segment. Character-

istically, fragmentation occurs just posterior to the beginning of the midregion.

There are no defined parapodia. The setae appear to arise from depressed areas on the body surface, and the bulging of the body surface anterior and posterior to these areas may give the impression of parapodia, with pre- and postsetal lobes (Figs. 1b, 1d, 1e). A ring of thickened tissue surrounds each area of setal insertion (Fig. 1c, TR).

Setae are all simple and vary from capillary to narrowly limbate. They are inserted in two vertical series; the anterior series are composed of coarser setae which are directed from perpendicular to the body axis to slightly posterior of perpendicular; the posterior series consist of slightly finer setae which are swept posteriorly.

The prostomium is conical and devoid of appendages (Fig. 1a), and no sense organs such as eyespots or Thulin's (1921, p. 4) "knopfenförmiges Organ" (button-shaped organ) have been observed. Near its base the prostomium bears a transverse furrow (Fig. 1a, PF), which, as both Eliason and Thulin have observed in *C. longocirrata*, gives a misleading impression that the basal portion is an achaetous segment. In both cleared whole mounts and frontal sections it is seen that the longitudinal muscle bundles are inserted at this point. It seems probable that the furrow is produced as these muscles contract at fixation. The peristomial segment has neither setae nor appendages. The next segment, the 1st setiger, bears a bundle of about six setae on either side. These are nearly perpendicular to the body axis, and their tips are slightly curved posteriorly. The 2d setiger bears a single dorsal median cirrus at its posterior border.

The cirrus remains attached throughout preservation and subsequent washing, but the tip is easily broken off. In one case, a preserved fragmented specimen of 21 segments (3 mm) possessed a cirrus 14 mm in length. Near its point of attachment the cirrus is constricted slightly; it then enlarges to its maximum diameter at the level of the 9th setiger and tapers gradually to its free end. In preserved specimens the cirrus shows a central core of muscle fibers running throughout its length, and the surface epithelium is circularly wrinkled as if it were capable of extreme extension when living. In life the cirrus trails close to the dorsal surface of the body.

The 2d to 6th setigers carry approximately 12 setae on either side (Fig. 1b), and all setae, to the 6th setiger, appear to arise with no indication of noto- and neurosetal bundles. The dorsal setae of these anterior setigers project laterally (most of them are in the anterior series), while the more ventral ones tend to be inclined posteriorly (the posterior series). Further along the body, the dorsal setae become recurved and the ventral setae become more recurved until they are almost parallel to the body surface (Fig. 1c). At about the 7th to 8th setiger, it is possible to differentiate noto- and neurosetal bundles and the number of setae increases to 16–18 per side (Fig. 1d). This number and disposition continue through the remainder of the anterior region to about the 17th to 19th setiger.

The midregion is characterized by longer segments and, in the case of ovigerous females, by the presence of many large eggs. The setae in this region arise in the middle of each segment and are slightly recurved. There are from 4 to 6 notosetae and a like number of neurosetae in this region (Fig. 1e).

In the posterior region the number of setae is gradually reduced from 4–6 in each bundle to 2 notosetae and 2 neurosetae on each side in the segments just preceding the pygidium. In the posterior region, the setae are directed more and more anteriorly as the anal segment is approached. In preserved material, the segments of the ovigerous and following region take on a moniliform appearence, which has not been observed in living material.

The eggs are oval and up to 140 micra long by 100 micra wide. A single segment may contain as many as forty eggs. All specimens large enough to be considered mature and which had not fragmented anterior to the ovigerous region, contained eggs. Unequivocal males have not been observed.

The pygidium or anal segment (Fig. 1f) is cleft in the dorso-ventral plane to form two lateral lobes (AL). It has three long cirri (PC) up to 0.7 mm in length (approximately as long as the last 10 segments). Two of these are inserted dorsolaterally on the outer surface of the anal lobes; the 3rd is inserted ventrally, where the lobes join. Along the margin of each anal lobe are 6–10 fingerlike processes approximately 0.1 mm long (PP). No mention of these is made by either Webster and Benedict (1887) or Thulin (1921) in their descriptions of *C. longocirrata*, or by Hartman (1955a) in her description

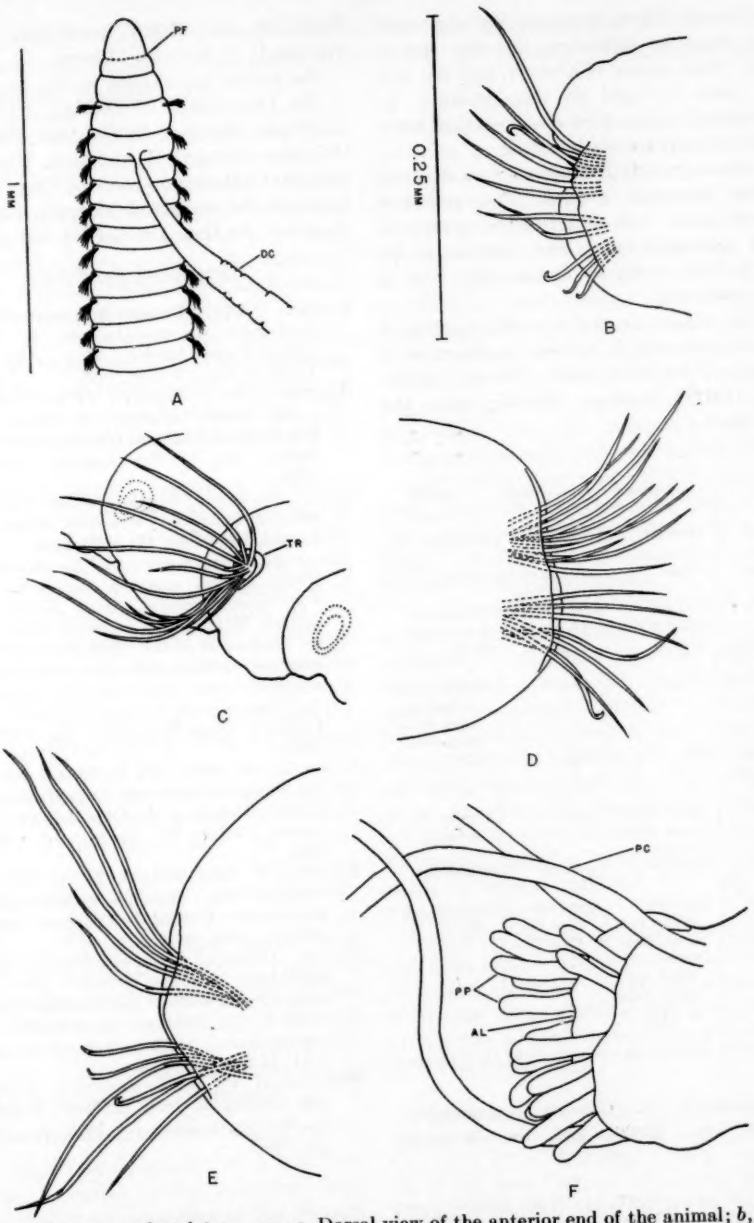

FIG. 1.—*Cossura pygodactylata*, n. sp.: *a*, Dorsal view of the anterior end of the animal; *b*, 5th right setiger in anterior view (setae appear bent or hooked in the figures to indicate their curving posteriorly); *c*, 5th right setiger in dorsolateral view, dotted areas show the position of the setal bundles of the 4th and 6th setigers; *d*, 9th left setiger in anterior view; *e*, 25th right setiger in anterior view; *f*, lateral view of the pygidium. Figures 1c, 1d, 1e, and 1f are to the same scale as 1b. (Abbreviations are as follows; AL—anal lobe; DC—dorsal cirrus; PC—pygidial cirrus; PF—prostomial furrow; PP—pygidial processes; and TR—thickened ring of tissue.)

of *C. candida*. These processes are the most obvious character separating the new species from the other species of *Cossura*, and the new specific name is based on their presence. In living animals it has been observed that these pygidial processes are not retractile.

Unfortunately, only 2 specimens were observed with the proboscis everted. The proboscis apparently has 4–8 finger-shaped processes directed anteriorly, and they appear to be similar to those shown by Thulin (1921, Fig. 2) for *C. longocirrata*.

A table comparing the described species of *Cossura* is presented. It is based on the work of Webster and Benedict (1887), Eliason (1920), Thulin (1921), Hartman (1955a), and the present description.

	C. longocirrata	*C. pygodactylata*	*C. candida*
Insertion of cirrus	2d setiger	2d setiger	3d setiger
Pygidial processes	Absent	6–10 on each anal lobe	Absent
Length	6–12 mm	6–7 mm	7–10 mm
Width	0.35–0.8 mm	0.3 mm	0.5–0.7 mm
Number of segments	50–70	43–56	50–75
Sense organs on prostomium	Present	Absent	Nuchal organs present at sides of prostomium.[1]
Number of setae per segment	8–18	8–18	12–16
Character of tube	Thin, rather long, membranous	None	Present on some.[1]
Depth where found	6–120 feet	3–30 feet	36–2640 feet
Distribution	Eastport, Maine; Øresund, Denmark; North Atlantic; coast of Chile.	San Francisco Bay, Calif.	Southern California.

[1] According to personal communication from Dr. Olga Hartman.

The holotype of *Cossura pygodactylata* (U.S.N.M. no. 27609) and the paratypes (U.S.N.M. no. 27610) have been deposited with the U. S. National Museum.

The author is indebted to Dr. Cadet Hand, of the Department of Zoology, University of California, Berkeley, to Dr. Olga Hartman, of the Allan Hancock Foundation, University of Southern California, and to Mrs. Elise Wesenburg-Lund, of the Zoological Museum, Copenhagen, Denmark, for their kind advice and criticism.

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MAMMALOGY.—*Two new long-tailed pocket mice* (Perognathus formosus) *from Arizona*. E. LENDELL COCKRUM, University of Arizona. (Communicated by Charles O. Handley, Jr.)

In the summer of 1953 I spent some time in Washington, D. C., studying the mammals from Arizona in the collections of the United States National Museum (including the Biological Surveys collection). Long-tailed pocket mice occur, in Arizona, only in the Arizona "strip," that is, the area north and west of the Colorado River. Attempts to determine the subspecific status of the specimens in the Biological Surveys collection revealed the presence of two heretofore unnamed subspecies. The following descriptions were, in part, prepared at that time.

In December 1953 I visited the Museum of Vertebrate Zoology, at the University of California, Berkeley, California. In this collection are a number of long-tailed pocket mice from Arizona. Discussion with Dr. Seth B. Benson revealed that, on the basis of the specimens in that collection, he had recognized the presence of the two unnamed subspecies. Dr. Benson has kindly given me permission to publish the descriptions, incorporating the data available from the specimens in his care.

Grateful acknowledgement is made to the National Science Foundation for a research grant (G-333, Investigations of the Mammals of Arizona) for financial assistance; to Drs. Remington Kellogg, David Johnson, and Henry Setzer, of the U. S. National Museum; to Dr. John W. Aldrich and Miss Viola Schantz, of the U. S. Fish and Wildlife Service; and to Drs. Alden Miller and Seth Benson, of the Museum of Zoology at Berkeley for permission to examine the material in the collections under their care as well as for their personal kindnesses.

Perognathus formosus domisaxensis,[1] n. subsp.

Type.—Adult female, skin and skull, U.S.N.M. no. 249006, Biological Surveys collection; from Houserock Valley, 15 miles west of [the Navajo] bridge, Coconino County, Ariz., collected August 6, 1929, by Vernon Bailey, original number 10758.

Distribution.—Insofar as is now known, this subspecies occurs in Arizona west of the Colorado River, north of the Kaibab Plateau, south of the Paria Plateau, and east of the Kanab Plateau.

Diagnostic characters and comparisons.—A small-sized race of *Perognathus formosus*. Similar to *P. f. formosus* in general color but much smaller in size (see measurements). The occipitonasal length, the frontonasal length, the length of the bullae, and the basilar length are all less than in *P. f. formosus* or *P. f. mohavensis*. The auditory bullae are least inflated in *P. f. domisaxensis*, but the inflation of the brain case is, proportionally, about as in *P. f. formosus*.

Color.—Basal portions of hair near Gray (Gull Gray)[2]; subterminal band close to Light Buff; terminal portion of hairs tipped with dusky. The color of subterminal portion dominates the color of the dorsal surface.

Measurements.—Type: Total length, 185; tail vertebrae, 111; hind foot, 24; ear, 11. Two topotypes, 1 male and 1 female, respectively, 184, 175; 105, 100; 23, 23; 11, 11. *Skull* (type, followed by measurements of 1 male and 1 female topotype): Occipitonasal length, 25.3 (00.0, 24.9); frontonasal length, 16.9 (00.0, 16.8); mastoidal breadth, 13.6 (13.6, 13.5); length of bulla, 8.7 (8.6, 8.2); interorbital constriction, 6.6 (6.4, 6.5); alveolar length upper tooth row, 3.8 (3.6, 3.7); length of interparietal, 3.7 (3.4, 3.4); width of interparietal, 6.4 (6.1, 6.0); basilar length, 18.1 (17.9, 17.5).

Remarks.—Two of the three specimens from the type locality show considerable rosaceous staining. This strain is evident on the usually white hairs of the venter as well as on the dorsal surface. As a result these appear to be much lighter and brighter.

Specimens examined.—Total, 32, distributed as follows: 6 mi. se. of Fredonia, 1, BS; Houserock Valley, 15 mi. w. of Bridge, 3 (BS); Soap Creek, 15 mi. sw. Lees Ferry, 1 (BS); 2 mi. w. of Lees Ferry (BS); 3,250 ft., 11 (MVZ); 6 mi. w. of Grand Canyon Bridge, Marble Canyon, 3,800 ft., 13 (MVZ).

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[1] From *domus*, house, and *saxum*, rock, as this subspecies is known from Houserock Valley.

[2] Capitalized color terms after Ridgway, *Color standards and color nomenclature*, 1912.

Perognathus formosus melanocaudus, n. subsp.

Type.—Adult female, skin and skull, U.S.N.M. no. 262918, Biological Surveys collection; from the lower end of Toroweap Valley (Rim of Grand Canyon), Mohave County, Ariz.; collected July 30, 1937, by Luther C. Goldman, original number 341.

Distribution.—In so far as is now known, this subspecies is restricted to the region of the type locality.

Diagnostic characters and comparisons.—A dark-colored race of *Perognathus formosus* (similar to *P. f. formosus* in general size (see measurements) but auditory bullae and brain case more inflated and interorbital region more constricted; distinctly darker in general dorsal coloration including dorsal part of tail. These same conditions are evident when comparisons are made with *P. f. mohavensis* and *P. f. domisaxensis.*

Color.—Basal portions of hairs near Gray (Dark Dull Gray), Gray (Gull Gray) in *P. formosus formosus* and *P. f. domisaxensis*; subterminal band close to Pinkish Buff is quite narrow; terminal portion of hairs tipped with black. The basal and terminal colors dominate the color of the dorsal surface.

Measurements.—Type: Total length, 190; tail vertebrae, 111; hind foot, 25. Two adult female topotypes, as follows: 193, 188; 104, 108; 24, 24. *Skull* (type and two adult female topotypes) Occipitonasal length, 26.7 (26.5, 26.2); frontonasal length, 18.3 (18.1, 17.7); mastoidal breadth, 14.4 (13.9, 14.4); length of bulla, 9.0 (8.9, 8.8); interorbital constriction, 6.4 (6.3, 6.7); alveolar length upper cheek teeth, 3.8 (3.9, 3.8); length of interparietal, 3.7 (3.9, 3.8); width of interparietal, 6.0 (6.1, 6.3); basilar length, 18.2 (18.5, 17.8).

Remarks.—The series of animals in the Biological Survey collection from the Toroweap Valley all show signs of molting. Further, most of the animals were young when taken. However, the young are much darker than those of similar age and pelage condition from all other localities represented.

Specimens from four miles north of Wolf Hole and 12 miles north of Wolf Hole, here referred to *P. f. formosus*, are intergrades between *P. f. melanocaudus* and *P. f. formosus*. This is demonstrated by the intermediate nature of the inflation of the auditory bullae, inflation of the braincase, interorbital width, and pelage color.

Specimens examined.—Total, 52, as follows: Lower end of Toroweap Valley, 16, BS; Lower end of Toroweap Valley, 4200 ft., 36, MVZ.

Comparative material—Perognathus formosus formosus: UTAH: St. George, 17 (BS). ARIZONA: 4 mi. n. of Wolfe Hole, 1 (BS); 6 mi. n. of Wolfe Hole, 4,900 ft., 4 (MVZ); 10 mi. n. of Wolf Hole, 3,800 ft., 10 (MVZ); 12 mi. n. of Wolf Hole, 3,500 ft., on road to St. George, Utah, 17 (BS). *Perognathus formosus mohavensis:* ARIZONA: Near mouth Beaverdam Creek, 1,500 ft., just above Little field, 1 (BS); Grand Wash, 1,800 ft., 8 mi. s. of Pakoon Spring, 1 (BS). CALIFORNIA: Oro Grande, 37 (BS).

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

PHILOSOPHICAL SOCIETY

1397TH MEETING, OCTOBER 8, 1954

WILLIAM SHOCKLEY, of the Bell Telephone Laboratories, spoke on *Transistor physics.*

Transistor physics is the modern name for that branch of solid-state physics that treats semiconductors. The particular material discussed was germanium; its four valence electrons cause it to crystallize in the same structure as diamond. The perfect lattice of pure germanium is analogous to a vacuum; various defects act like free particles in a vacuum. The six known imperfections that contribute to the semiconductor behavior are:

(1) An excess electron.
(2) A "hole," or missing electron.
(3) Deathnium, which may be an atom of copper or nickel, or simply a structure defect. Deathnium is a generic name for centers which catalyze hole-electron pair generation and recombinations.
(4) A donor atom, which acts like a bound or anchored "hole."
(5) An acceptor atom, which is a bound negative charge, creating a freely moving "hole."
(6) A trap, which is a bound charge in a low dielectric constant crystal, and therefore tends to attract and hold free charges.

The apparent motion of a hole in an applied electric field is produced by the motion of an electron that fills the hole, and leaves a new one

elsewhere. Surprisingly, the mobility of holes is almost as great as the mobility of electrons.

Semiconductors exhibit photoconductivity. Incoming photons release valence electrons, making the crystal conducting until the electrons recombine with holes. The density of deathnium recombination centers in such that this induced conductivity decays with a half-life in the range of 1 microsecond to 1 millisecond.

If an impurity having 5 valence electrons is present, it donates a free electron, and the donor atom becomes positively charged but held in position in the lattice. The donor atom is therefore a bound hole. Since the conductivity is due to free electrons, or negative charges, such impure germanium is called n-type. Conversely, an impurity such as Gallium, with three valence electrons, in an acceptor. The gallium atom becomes a bound negative charge and contributes a free hole, making p-type germanium.

In the case of a relatively low dielectric constant crystal such as silicon, the bound negative acceptor atom acts as a trap for holes. Under photon bombardment hole-electron pairs are created, and the holes are trapped, leaving free electrons for conductivity. With the photon source removed, this conductivity persists until the holes escape the traps and recombine with the electrons at deathnium centers. The time constant of this conductivity decay ranges from several seconds to a minute.

The melt-grown process for making P-N junctions was described. The internal potential field that maintains equilibrium was explained graphically. Application of an external field to increase to very small current or large current respectively, yielding a rectifier action. Illumination of the n-type region generates hole-electron pairs; the holes slide down the potential hill to the p-type region, making this more positive. Such a system acts like a battery, and in fact has been made as a solar battery with a conversion efficiency of greater than 5 percent.

This junction discussion was extended to the case of the n-p-n "sandwich" transistor. The potential curve in this case resembles a dam, and illustrates vividly how gain is obtained. In the water analog, raising the reservoir bottom slightly yields a large increase in the water-wheel power available. Such n-p-n transistors can operate say as audio oscillators, at the fantastically low power input of one microwatt. This is approximately the average power expended by a common dog flea jumping up 50 cm, once every 10 seconds! (*Secretary's abstract.*)

1398TH MEETING, OCTOBER 22, 1954

The Society was addressed by S. A. SCHAAF, of the University of California, on the subject *Aerodynamics at very high altitudes.*

At sufficiently high altitudes, the air is a rarefied gas. For aerodynamic purposes, a gas is definitely rarefied when the mean free path of its molecules is greater than 1 percent of some significant parameter of the flow field, such as the boundary layer thickness, the shock wave thickness, or the missile size. Under such conditions, aerodynamics becomes a problem in molecular dynamics. The design of a supersonic wind tunnel operating at a pressure of 10^{-4} atmospheres was described, and the experimental techniques and results discussed. Such a low air density makes Schlieren photos impossible, and so a new technique was used to make the flow pattern visible. Air or nitrogen ions are introduced upstream; a variable intensity afterglow develops in the flow and provides a self-luminous pattern.

Simple theory indicates that the maximum temperature reached by the nose of a missile should be the adiabatic molecule stopping temperature, the temperature corresponding to the impact velocities of the molecules. It was observed, however, that for sufficiently thin air, higher temperatures were reached. This molecular impact heating makes possible an interesting new probe. The probe is a very fine wire, much less than a mean free path in diameter, so that it cannot affect the flow. The impact heating increases the resistance of the wire. This is the converse of the cooling of a hot wire used in ordinary wind tunnels. Such a wire was used to probe the internal structure of a shock wave.

Navier-Stokes theory says that a shock wave should be three or four mean free paths thick. The behavior is different for monatomic and diatomic gases. Diatomic gases possess rotational degrees of freedom, that may or may not come into equilibrium with the translational kinetic energy during the time the molecules are in the shock wave. If the equilibrium is slow in being established, a gas behaves as though it is monatomic. Expansion of a monatomic gas is friction-

less; if the rotational states get into equilibrium, there is a frictional effect which is quantitatively introduced by a bulk viscosity constant. Experiments up to speeds of Mach 4 show shock waves that fit almost too well with the Navier-Stokes theory including bulk viscosity. It is concluded that this theory is adequate, and that rotational equilibrium is established quickly, in air. (*Secretary's abstract.*)

1399TH MEETING, NOVEMBER 5, 1954

The Society was addressed by S. F. SINGER, of the University of Maryland, on the topic *The age of meteorites.*

One hundred and fifty years ago, it was not generally believed that meteorites existed. It was in 1803 that a proof was presented to the French Academy that meteorites are of extra-terrestrial origin.

Meteorites are of two types, with some mixed samples, METAL meteorites consist primarily of iron, with up to 20 percent of nickel. STONE meteorites are primarily silicates, and appear to be the slag that collected on the surface when the large mass of molten material solidified—the mass that later broke up into meteorites. About one ton per day is the earth's total accretion rate. Most meteorites are small, but there is a 60 ton metal one in South Africa.

Meteorites are probably parts of asteroids, or small planets. The first evidence of this comes from their low impact velocities, characteristic of nearly circular orbits around the sun. On the other hand, meteors have very high velocities, approximating solar escape velocity, so are probably parts of comets. Indeed, meteor showers often coincide with comet approaches. Conversely, if meteorites were from outside the solar system, their impact speeds would probably burn them up in the earth's atmosphere.

Cutting, polishing, and etching meteorites reveals beautiful crystalline structure patterns, known as Widmanstaetten figures. These patterns can be reproduced in the laboratory by slow cooling of an iron-nickel melt; the patterns thus produced, however, show smaller crystals. It is concluded that meteorites were once liquid, and cooled very slowly under high pressure. Such conditions would be found in the interiors of small planets, of say 500 miles diameter. The structure of iron meteorites also shows definite evidence of shock wave passage, suggesting the break-up of such a planet. The silicate meteorites would then be pieces of the slag that became the crust of the planet.

Attempts have been made to date the solidification of meteorites by measuring the concentrations of U-238 and helium. U-238 has a decay half-life of 4½ billion years; a typical meteoritic concentration in a 1-gram sample is 10^{-8} grams of uranium, and 10^{-6} cc of helium, referred to normal temperature and pressure. This method, with its attendant delicate helium determination, was developed by Paneth. As to the possibility that most of the helium had leaked out, Paneth eliminated this by heating meteorites to 1,000°, and finding that although helium leaked badly from stone, only 5 percent was driven out from iron meteorites.

One thoroughly tested meteorite had an apparent age of 8 billion years by this method, about twice the age of the universe! And a correction for assumed helium leakage would INCREASE this figure! A suggestion made some years ago that cosmic ray bombardment had produced the apparent excess helium had been discarded, because the estimated yield was too low. This thought was revived by Singer in view of the modern knowledge of pi-mesons, etc. Both primary photons and secondary mesons knock alpha particles out of the iron nucleus, thereby producing helium. Theoretical calculations yield a curve for helium yield vs. depth from the surface, with a broad peak some 2–15 cm in. Even more useful is the prediction of one atom of He-3 for every two of He-4 produced, an isotope ratio over a million times larger than in the earth's atmosphere. The "8-billion year" meteorite has 31 per cent of its helium in the He-3 form, hence practically all its helium is of cosmic-ray origin, and the age data are meaningless. Meteorites exhibiting a lower percentage of He-3 can be evaluated by subtracting the 2-to-1 correction, and dating by the remaining radiogenic helium.

On the other hand, if we assume that the average cosmic ray intensity seen by a meteorite in its flight has been sensibly constant, we can consider the meteorite as an integrating cosmic ray exposure meter and compute the duration of its exposure. Unfortunately, the corrected radiogenic age estimate runs around 100 million years for a number of specimens but their apparent exposure time has been 300 million years, hence a new paradox has replaced the old one.

A new hypothesis has been put forward. It

states that the radiogenic helium leaks out badly, because the Uranium is concentrated on grain boundaries, and the cosmic helium does not leak out. This is compatible with Paneth's experiment, for his helium leakage test was on a specimen that later was found to contain only cosmic helium, judging from the 31 per cent He-3 content. A crucial test would be to find a specimen having about half cosmic and half radiogenic helium, and heat it. If the hypothesis is correct, the He-3 to He-4 ratio should increase.

It now appears feasible to measure the radiogenic Pb-206 and ordinary Pb-204 contents, and date by this means. This should yield the time of solidification, whereas the cosmic helium measurements should yield the time of break-up. (*Secretary's abstract.*)

1400TH MEETING, NOVEMBER 19, 1954

LESLIE S. G. KOVASZNAY, of Johns Hopkins University, spoke on *Image processing by electro-optical techniques.*

A picture can be regarded as the representation in the plane of a function of two independent variables. A transformation of the independent variables corresponds to a distortion. Operators on the function correspond to a process. By the application of electro-optical scanning techniques to a picture the elements are converted into electrical quantities and can be subjected to various operator functions. The speaker's work in this field was not induced by any considerations of television but rather by a desire to understand more about the mechanism of vision. The corresponding study of the mechanism of hearing has been greatly aided by the application of electronic circuits which suppress certain frequencies or make other distortions of the original sound. In the visual case electro-optical scanning was chosen because it is much more flexible than photography. A still more sophisticated approach would be to make use of a computer, which could then perform any desired set of operations on the elements of a picture.

The system devised by Mr. Kovasznay has been brought to experimental realization under his direction at the National Bureau of Standards. One requirement called homogeneity limits the operator functions which may be used. A second requirement called isotropy prevents the television-type of scanning from being used. To overcome this difficulty a special system of sawtooth waves of slightly different frequencies is used in scanning. The result is that a given point is scanned first along a line making a 45° angle with the frame, then along a line at right angles to the first, then along the first line in the opposite sense and finally along the second line in the opposite sense.

Electric circuits produce first and second derivatives of the function represented by the picture. The difference between the function and its second derivative is a deblurring operator which can be used to sharpen the contrast in photographs. Examples were shown where this has been accomplished, including an X-ray photograph of the heart. Outline drawings can be produced from photographs by using the first derivative alone. The derivative is rectified and applied to a trigger circuit to obtain lines to constant intensity.

The system can also be used in the study of operators and filters in 2-dimensional arrangements. A considerable number of possible applications were outlined. (*Secretary's abstract.*)

1401ST MEETING, DECEMBER 3, 1954

FRANÇOIS N. FRENKIEL, of the Johns Hopkins University Applied Physics Laboratory, addressed the Society on *Atmospheric pollution.* The five basic factors are:

(1) Production of pollutants.
(2) Emission.
(3) Transfer by atmosphere.
(4) Chemical changes en route.
(5) Deposition from atmosphere.

The paper discussed some details of the third factor: the fluid dynamics and meteorology of pollution. The complicated fluid motion of the atmosphere requires so many iterative applications of complicated equations that more artistic means are needed, partly science and partly intuition or art. Electronic computers, however, allow a brute force attack.

Atmospheric pollution can be responsible for much suffering. One week of London smog in 1952 increased the weekly death rate from 1,000 to 2,500, mostly in circulatory and respiratory diseases. The recent Los Angeles and Pasadena smog fortunately had no such result, but might at another time.

The pattern of smoke from chimneys can be averaged over a long time to obtain its mean concentration distribution and is generally ellip-

tical. Each smog puff from each chimney moves with the wind and disperses. Eventually an equilibrium condition is reached at some distance from the sources.

The wind at Los Angeles reverses direction between 5:30 a.m., and 9:30 a.m., and thereafter shifts gradually with a fairly consistent pattern. Considerable numerical integration of wind velocity data yields the effects produced by an assumed distribution of sources. The Los Angeles area is a half bowl, bounded by mountains. The sea breeze blows into the open side of the bowl. A temperature inversion stops upward diffusion and currents, thereby putting an effective lid on the bowl, trapping and concentrating pollutants.

Computations have been made, using what wind velocity and smog diffusion data were available, and assuming various sources, such as a point source at Long Beach or automobiles in Los Angeles. The resulting concentration contours were shown, and agreed roughly with observed smog conditions. The effect of oxidization of hydrocarbons by solar radiation was added, and the resulting distribution also shown.

The rough agreement of these computations with reality indicate that a calculation with much more data would be valid and useful. Such computations can be made in a reasonable time by using electronic computing machines. Fast computation should be useful for predicting an approach to the danger level, and indicate which sources should be shut down until conditions change. Computation should also be useful in planning the development of a region, as to which parts are safest for industrial zoning, for example. (*Secretary's abstract.*)

1402D MEETING, DECEMBER 17, 1954

JOHN P. HAGAN, of the Naval Research Laboratory, spoke on *Radio sources and the structure of the galaxy.*

The material presented was based on studies of the radio spectrum of the heavens carried out at the Naval Research Laboratory with the 50-foot "Radio-telescope." Such studies depend largely upon the known properties of the hydrogen atom in radiation and absorption. Radio reception has supplemented ordinary telescopic observation, as for example in the neighborhood of Cassiopiea, where Mt. Wilson found diffuse luminous clouds of hydrogen after their existence had been detected by radio waves.

As is well known, our galaxy is pervaded with hydrogen atoms in various degrees of dispersal, varying from one atom per cc in the more diffuse parts of the galaxy arms to 100 atoms per cc in the hydrogen clouds and to very much higher figures in the stars themselves. The neutral hydrogen atom in this diffuse state absorbs and emits a radiation of about 21 cm wavelength (1,420.405 Mc). Both emission and absorption, of course, show appropriate doppler shifts with respect to an observer on earth. Studies were also made of the continuous spectrum at 21, 9.4, and 3.15 cm.

In addition to the line radiation there is a continuous background radiation, often called "white noise" (essentially independent of frequency, for not too wide bands), and also a number of "objects" that are much brighter than the diffuse hydrogen and that are at a temperature of tens of thousands of degrees. These sources seem to lie with few exceptions on the galactic equator. The diffuse hydrogen of the cold clouds has an effective temperature of about 100° K.

By analysing the radio spectrum in the neighborhood of the radio line as a function of both frequency and direction (i.e., Right Ascension and Declination), it is possible to win much information on the distribution of the hydrogen in the absorbing clouds that lie between a discrete radio source and the observer. In the case of Cassiopeia, absorption lines are seen corresponding to at least three clouds: one of which lies in the second arm of our galaxy and the other two in the first arm. The radio source itself lies at least in the second arm and probably beyond it. By using this technique the galaxy can be mapped in terms of such measurement, showing the hydrogen clouds and their relative velocities. Such mapping shows that the hydrogen is not loosely and unrelatedly distributed in the arms of the galaxy, but has many denser "cells" of 5–6 parsecs in diameter. The center of the galaxy, 8,000 parsecs away, displays a complicated absorption spectrum which was exhibited and discussed.

Further increases in resolving power depend upon larger diameter radio-mirrors, and it is hoped that when and if such mirrors are built it will prove possible to extend this type of spectrum analysis to lines from other elements, notably deuterium. (*Secretary's abstract.*)

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